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Technical Report

No. 13416

Repower and Regear of an M915 Line Haul Tractor to Demonstrate Feasibility of Commercial Electronic Controls and Air Starters

Contract DAAE07-85-C-R078

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M915 ATEC/DDEC DEMONSTRATOR
FINAL REPORT

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ABSTRACT

The M915 ATEC/DDEC Demonstrator Program consisted of the repower/regear of a U.S. Army M915 Linehaul Tractor, testing and demonstration/evaluation by the Government. The vehicle was repowered with a Detroit Diesel Series 60 engine and regeared with an Allison HT 755CR transmission. Both components included commercially-available electronic controls. Also included as part of the repower was a "Pow-R-Quik" engine air starter. The testing, demonstration, and evaluation was accomplished at several locations. Shakedown and vehicle performance testing occurred at General Motors Proving Grounds in Milford, Michigan. High Altitude Electro-Magnetic Pulse (HAEMP) testing was performed at the Government's White Sands Missile Range and is covered in a separate, classified Appendix to this report. Demonstrations for the Government took place at Milford Proving Grounds and at the Tank Automotive Command in Warren, Michigan. End user evaluation of the demonstrator vehicle was carried out at Fort Campbell, Kentucky.

M915 ATEC/DDEC DEMONSTRATOR FINAL REPORT

1.0 INTRODUCTION

This final technical report, prepared by Allison Transmission Division (ATD) of General Motors for the U.S. Army Tank Automotive Command (TACOM) under contract DAAE07-85-C-R078, describes the retrofit, testing, and demonstration/evaluation of an M915 Linehaul Tractor equipped with engine and transmission electronic controls and an engine air-start system (see Figure 1-1). The test vehicle was repowered with an electronically-controlled Detroit Diesel Series 60 engine, regeared with an Allison HT 755CR transmission with electronic controls, and equipped with a "Pow-R-Quik" air starter. The testing, demonstration, and evaluation were accomplished at GM's Milford Proving Grounds (GMPG), U.S. Army's White Sands Missile Range, and Fort Campbell, Kentucky, with the objective to determine the acceptability of the above components for use in tactical military vehicles.

2.0 OBJECTIVES

- Remove existing engine and transmission (if necessary) from the Government Furnished Equipment (GFE) M915 truck.
- Modify the GFE M915 test/demonstration vehicle to accept the new engine, transmission, and air starter. These modifications involve, but are not limited to, body/chassis, cooling, air induction/exhaust, and electronics/wiring.
- Consign and install in the GFE M915 a Detroit Diesel Series 60 engine which will provide 400 GHP at 2100 RPM governed speed.
- Consign and install an Allison HT 755CR transmission.
- Provide and install a "Pow-R-Quik" Model DS-23 air starter.
- Perform a shakedown test and functional checkout of the test vehicle at GMPG.
- Perform limited performance testing at GMPG.
- Make the modified M915 available for demonstration and evaluation by the Government at GMPG.
- Make the modified M915 available for Government High Altitude Electro-Magnetic Pulse (HAEMP) testing and further end user evaluation.
- Provide technical support for consigned engine and transmission during Government testing and evaluation.
- Address results of Government HAEMP testing in a separate, classified Appendix to this Final Report.

Figure 1-1. Demonstration of Electronically-Controlled M915

3.0 CONCLUSIONS

The modified M915 demonstrator vehicle was successfully equipped with the electronically-controlled Allison HT 755CR transmission, Detroit Diesel Series 60 and the "Pow-R-Quik" air starter. During performance testing, the vehicle exhibited enhanced operation and advanced engine/transmission diagnostics. The air starter was capable of starting the vehicle but its ability to perform a series of rapid restarts or extended engine cranking is questionable due to the limited air storage capacity. The U.S. Army troop familiarization usage evaluation was successfully performed at Fort Campbell, Kentucky.

The favorable results of the simulated High Altitude Burst Electro-Magnetic Pulse (HABEMP) testing, conducted at White Sands Missile Range, New Mexico, are covered in an Appendix (under separate cover) to this report.

4.0 RECOMMENDATIONS

4.1 Electronic Controls

This program has demonstrated the acceptability and versatility of Allison and Detroit Diesel electronic controls in military vehicles. It is recommended that future military vehicle specifications encourage the use of qualified electronic controls.

4.2 Air Starters

If air starters are going to be given further consideration for military vehicles, it is recommended larger air storage systems be investigated. The complications caused during deep water fording by the air system were not addressed and should also be investigated. Additionally, the ability to start one vehicle from another in a reasonable time should be evaluated.

5.0 DISCUSSION

5.1 Background

On 11 March 1986, Allison Transmission Division of General Motors received an M915 Linehaul Tractor (Registration number CF-8179; S/N OT-3814-45-10436) from the U.S. Army Tank Automotive Command for the purpose of demonstrating the acceptability in military vehicles of engine and transmission electronic controls, as well as air starters for diesel engines. To accomplish the above, the existing engine was removed (the vehicle had no transmission), the body and chassis were modified to accept the new components, and the new engine, transmission, starter, and accessories were installed.

The following sections of this report cover a brief description of the new engine and transmission, body/chassis modifications, electronic controls installation, performance testing, demonstrations/evaluation, and high altitude electro-magnetic pulse testing.

5.2 Engine and Transmission Description

5.2.1 Engine

5.2.1.1 General

The Detroit Diesel Series 60 engine is an advanced designed commercial diesel engine. It is a new product from the Detroit Diesel Corporation. The 6-cylinder, 4-stroke cycle is one engine with two displacements (11.1 and 12.7 liters), enabling power outputs ranging from 250 to 450 HP. The design simplicity of the Series 60, containing seven to thirty percent fewer parts than previous traditional engine designs, results in improved reliability and durability. Key features of the Series 60 include an overhead camshaft, parallel ports, an electronic control system and turbocharged air-to-air charge cooling (See Figure 5-1).

5.2.1.2 Intake and Exhaust

The intake and exhaust port configuration of the Series 60 is unique. The four valves per cylinder are located 90 degrees from what is seen on traditional engines. This parallel port configuration allows for very short, unobstructed intake and exhaust ports for efficient air flow, low pumping losses, and reduced heat transfer, allowing the engine to breathe more freely and run cooler.

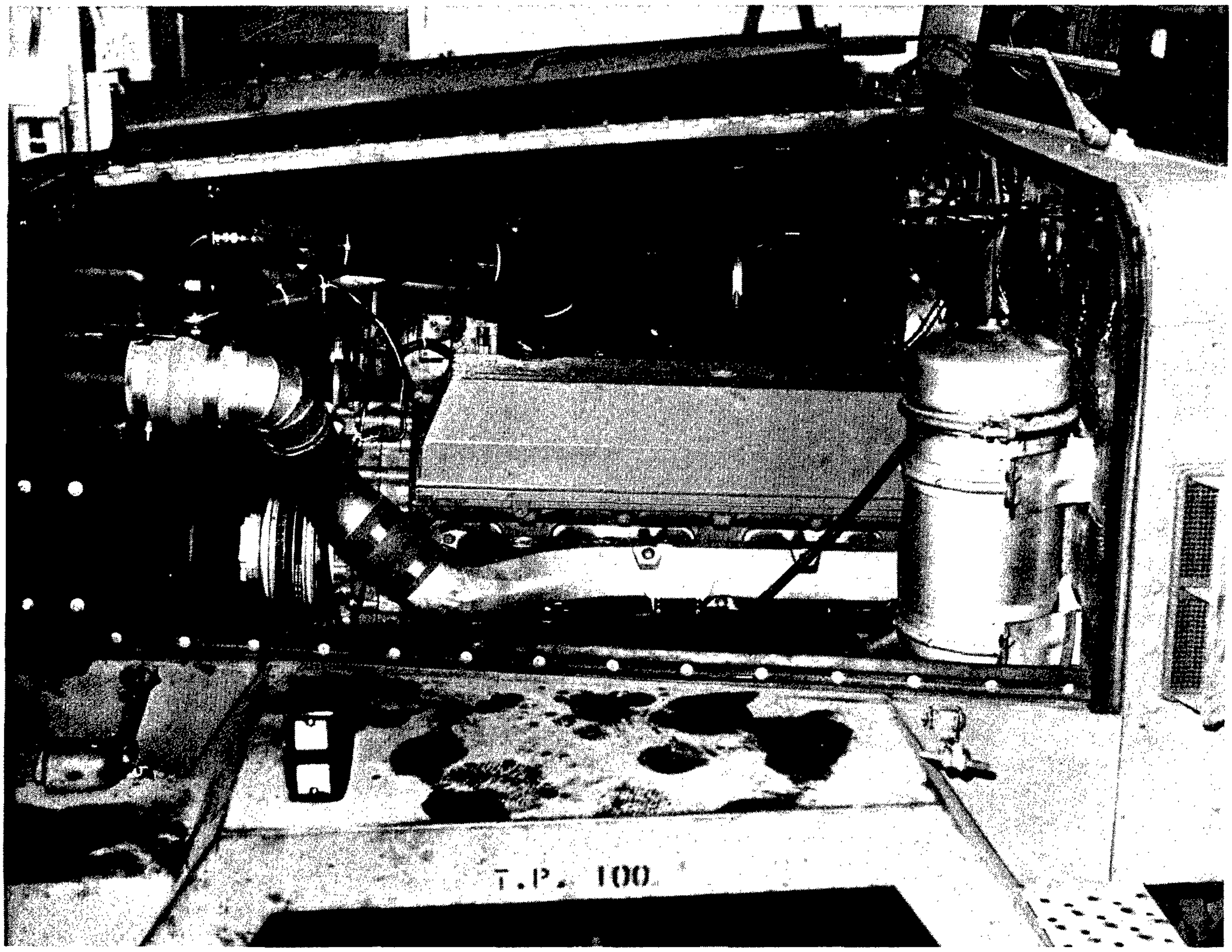

Figure 5-1. Series 60 Engine Installation

5.2.1.3 Air-To-Air Cooling System

To enhance fuel economy, the Series 60 has been designed to use air-to-air charge cooling. Air-to-air offers fuel economy gains of 2-5 percent over traditional intake air cooling systems. Incoming air is compressed by the turbocharger and directed to a finned heat exchanger in front of the vehicle's radiator. The heat exchanger uses no liquid coolant, but relies instead on ram air for cooling the charge air, resulting in lowering intake air temperature from approximately 300°F (149°C) to below 100°F (38°C). This cooler air aids combustion, thereby increasing fuel economy.

5.2.1.4 Overhead Cam System

The overhead cam design allowed Detroit Diesel to optimize the design of the intake and exhaust air passages in the cylinder head for easier breathing. By eliminating the push-rods and lifters, the fuel injection and valve operating system are stiffened. This results in precise control of injection and valve events.

The injector plunger is mechanically-actuated by the cam/rocker arm mechanism and generates up to 20,000 PSI injection pressure. The overhead camshaft assembly has relatively low contact stress, fewer parts, 40 less wear surfaces and special roller and lobe finishing. It is also a simpler design, making it much easier to service. As an added benefit of overhead camshaft construction, there was space available to accommodate eight head bolts per cylinder. Almost equally spaced, the head bolts provide a uniform load on the gasket and liner.

5.2.1.5 Detroit Diesel Electronic Controls

The Series 60 engine features integral electronic controls called Detroit Diesel Electronic Controls (DDEC). Its major components are the Electronic Control Module (ECM) and the Electronic Unit Injectors (EUI). The ECM is the "brain" of the system, receiving electronic inputs from the vehicle driver as well as engine-mounted sensors that provide information electronically, such as oil pressure and temperature, engine speed and intake manifold pressure. This information is used to control both the quantity of fuel injected and the injection timing.

The electronics contain a PROM (Programmable Read Only Memory) which is mounted in the ECM and encoded with the engine's performance characteristics. Included in the PROM is information to control the horsepower rating, torque curve, maximum engine speed, and optional protection devices. The ECM processes this information and sends electronic signals to the Electronic Unit Injectors where the precise amount of fuel is injected.

5.2.2 Transmission

5.2.2.1 General

The Allison HT 755CR transmission consists of a three-element torque converter, constant mesh planetary gearing and hydraulically-actuated multiple disc clutches with automatic gear selection in each range. The transmission is equipped with built-in downshift and reverse inhibitors and has provisions for mounting and/or operating a parking brake, power takeoff, speedometer drive, neutral start switch, and reverse signal switch. Two hydraulic retarder options and an engine-driven PTO option are also available. The HT 754CR transmission currently used in the M915A1 Linehaul Tractor and the HT 755CR transmission are identical with the exception of their controls. The HT 754CR uses hydraulic controls where the HT 755CR uses the Allison Transmission Electronic Control (ATEC).

5.2.2.2 Allison Transmission Electronic Controls

ATEC is a computer-based control system designed to control transmission functions including shifting and self-diagnostics. The main components of the ATEC system are the Electronic Control Unit (ECU), shift selector, throttle position sensor, electro-hydraulic valve body and wiring harnesses (see Figure 5-2). The ATEC controls replace the hydraulic valve body, output governor, throttle modulator and mechanical shift selectors used on earlier hydraulically-controlled transmissions.

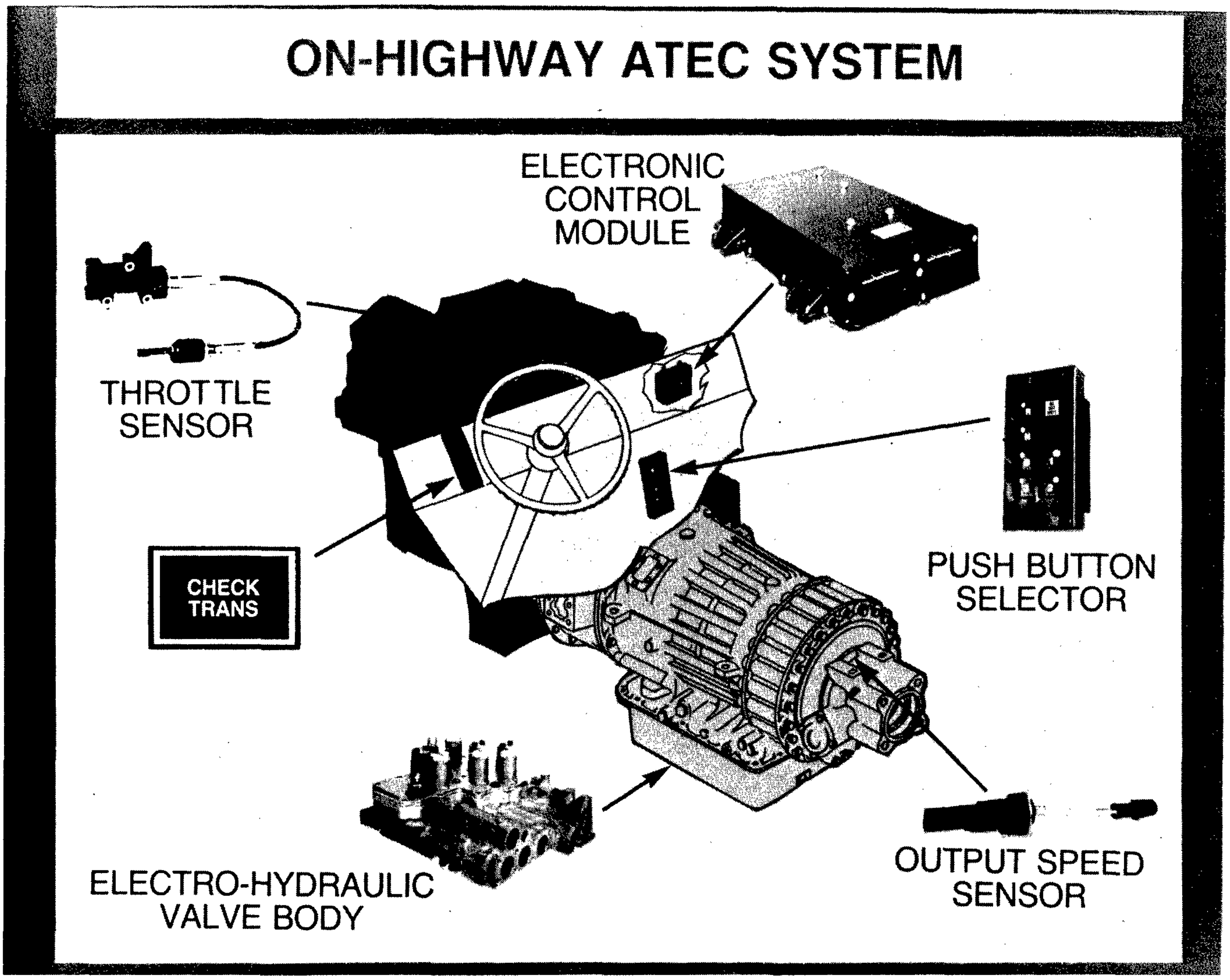

Figure 5-2. ATEC System Components

5.2.2.3 Electronic Control Unit

The Electronic Control Unit (ECU) is the "brains" of the ATEC system. It is a microcomputer which controls shifts based on throttle position, transmission output speed, shift selector position, sensors in the transmission and the programmed shifting logic. Within the ECU there is a Programmable Read Only Memory chip (PROM). This computer chip is programmed by ATD to match the vehicle requirements and allows the ECU to command shifts accordingly. There are two versions of the ECU depending on the application requirements.

5.2.2.4 Throttle Position Sensor

Shift modulation may be achieved by sensing a signal from a resistive sensor attached by cable to the fuel control lever or by a module that translates the throttle position signal which is transmitted by DDEC engine controls (the latter being used for this program). The signal is then converted to a percent throttle by the ECU. The ECU automatically adjusts the percent throttle conversion to compensate for installation tolerances and wear.

5.2.2.5 Electro-Hydraulic Valve Body

With ATEC, the flyweight governor, modulator cable and shift signal valves used on hydraulically-controlled transmissions are not required. The ATEC control valve body is common for all transmissions within a model. Shift characteristics are determined by constants programmed into the PROM instead of the springs and low pressure signals employed in hydraulic controls. ATEC controls result in a simplified valve body, more precise shifts and reduced transmission assembly inventory requirements as compared to similar hydraulically-controlled transmissions.

5.2.2.6 Diagnostics

Self-diagnostics and simplified service troubleshooting are also advantages of ATEC. The ECU monitors the entire ATEC system for indications of trouble. If a problem is detected, the controls will signal the operator through the "CHECK TRANSMISSION" light on the dash. For more serious trouble indications, a buzzer and light in the shift selector indicate that operation should be stopped and service performed immediately. Once a trouble indication is registered by the ECU, a code is stored in its memory. By using a service diagnostic tool (see Figures 5-3 and 5-4) and the service manual, the trouble area can be quickly isolated. Service time can be greatly reduced.

5.2.2.7 Abuse Protection

In addition, ATEC has standard abuse protection logic to inhibit operations which could be detrimental to the transmission, engine and vehicle. By notifying the operator when trouble is detected and inhibiting some operations that could be abusive, transmission life can be preserved.

Figure 5-3. Modified M915 Diagnostic Demonstration

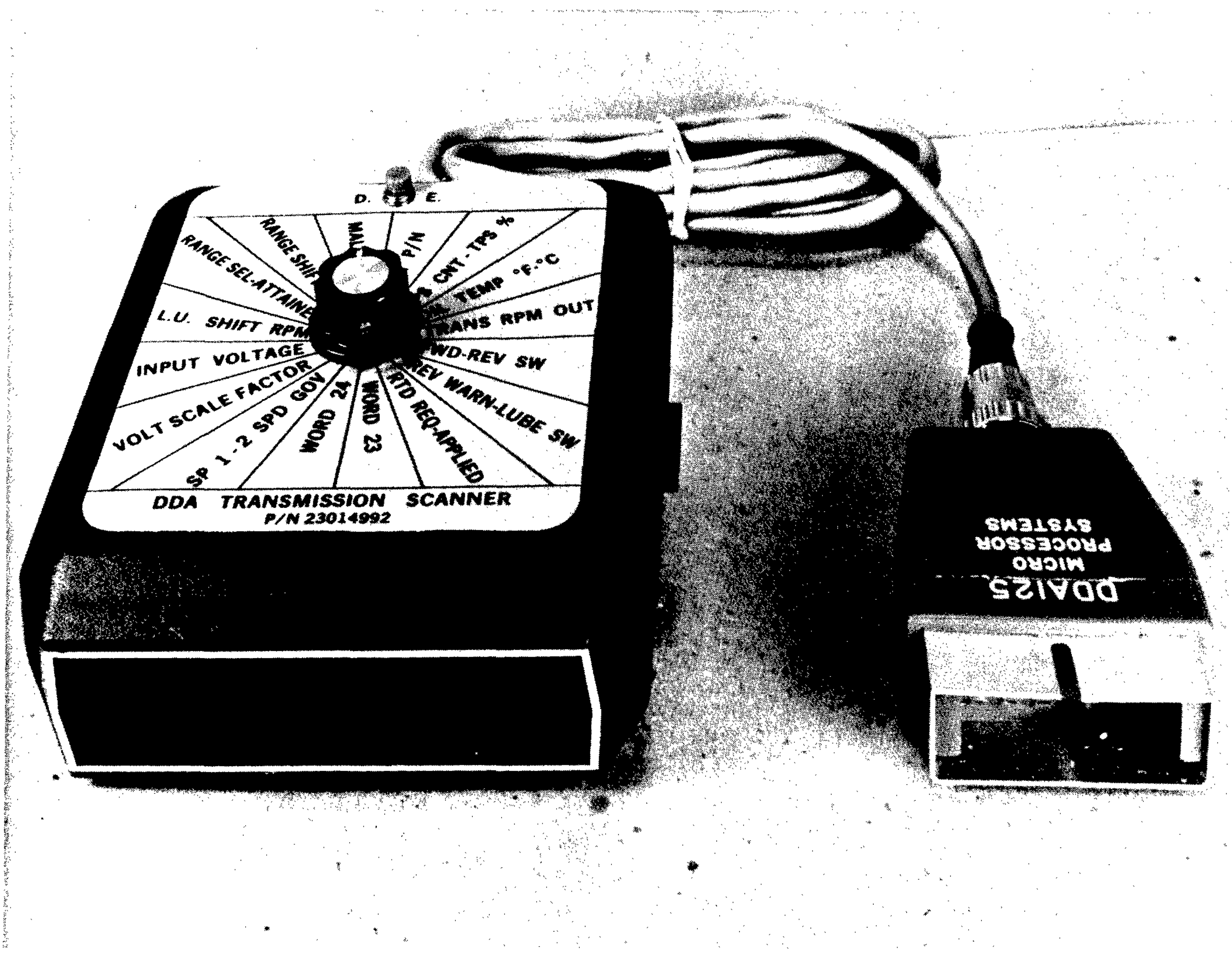

Figure 5-4. Transmission Diagnostic Tool

5.2.3 Controls

The Detroit Diesel Electronic Controls II (DDEC) and Allison Transmission Electronic Controls I (ATEC) were designed to commercial requirements with reference to MIL-STD-810, MIL-HDBK-217, and MIL-HDBK-253 for military requirements. Both systems were subjected to high altitude electro-magnetic pulse testing. The results of this test are covered in a separate Appendix to this report.

5.3 Body/Chassis Modifications

5.3.1 Cooling System

The portion of the tractor body/chassis needing the most rework for this installation was in the area of the radiator. The radiator was replaced, the transmission and power steering cooler relocated, and the engine's air-to-air cooler was added.

5.3.1.1 Radiator

The radiator supplied with the vehicle was replaced by the radiator assembly used in the M915A1. The new assembly incorporated a bottom tank cooler for the transmission and a combination air-to-oil cooler for transmission and power steering systems. Since the new assembly is five inches wider than the original assembly, rework of the mounting system was required.

5.3.1.2 Engine Air-To-Air Cooler

The Detroit Diesel Series 60 engine uses an air-to-air finned heat exchanger to cool the charge air. This heat exchanger was mounted on the front of the radiator (see Figures 5-5 and 5-6).

5.3.1.3 Transmission/Steering Pump Air-To-Air Cooler

On the M915A1 tractor, the transmission/steering pump air-to-air cooler is mounted in front of the radiator. On this vehicle, the charge air cooler was mounted in front of the radiator so the transmission/steering pump heat exchanger was relocated behind the radiator. The radiator bottom tank cooler for the transmission and air-to-air transmission cooler are connected in series.

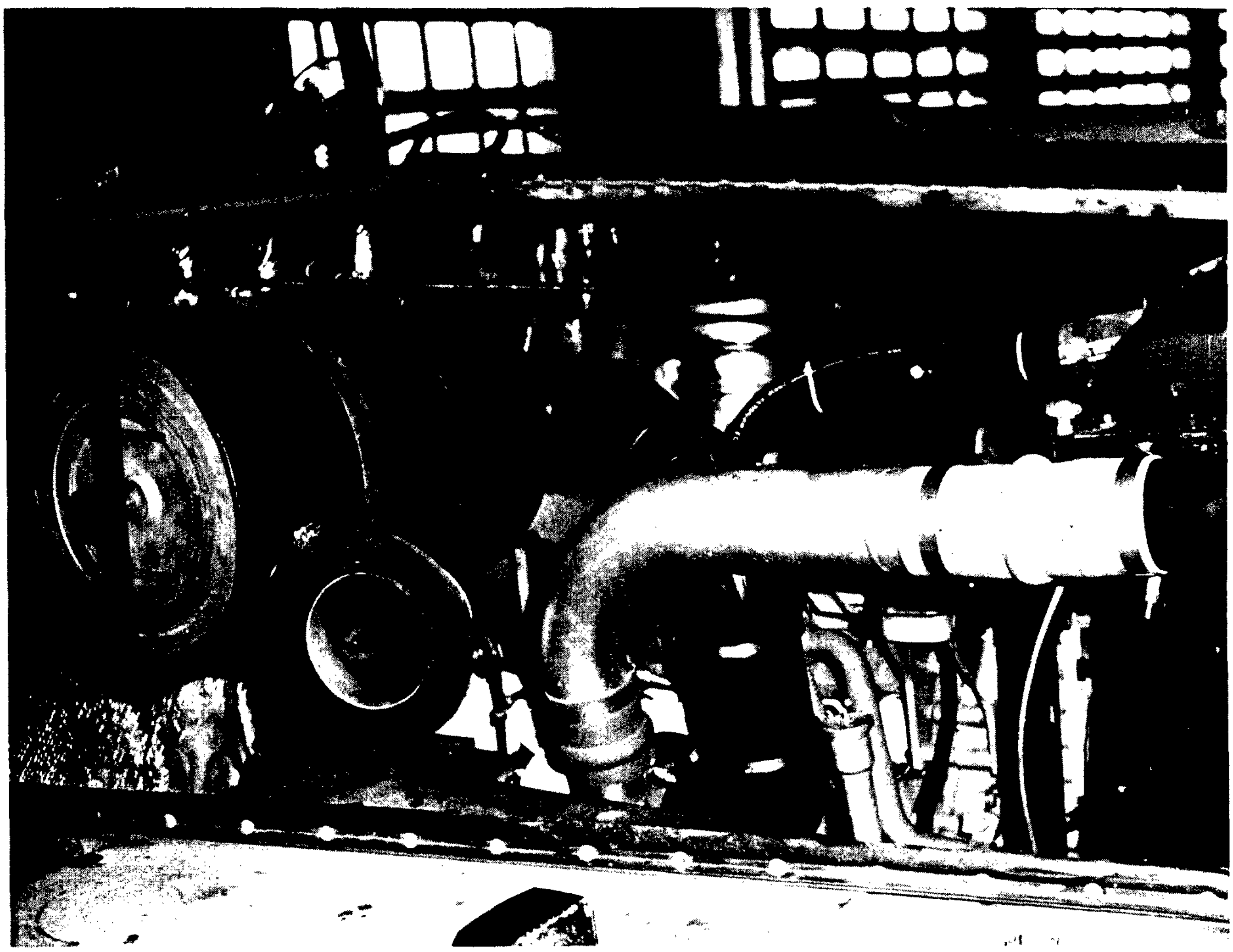

Figure 5-5. Charge Air Duct From Intake To Cooler

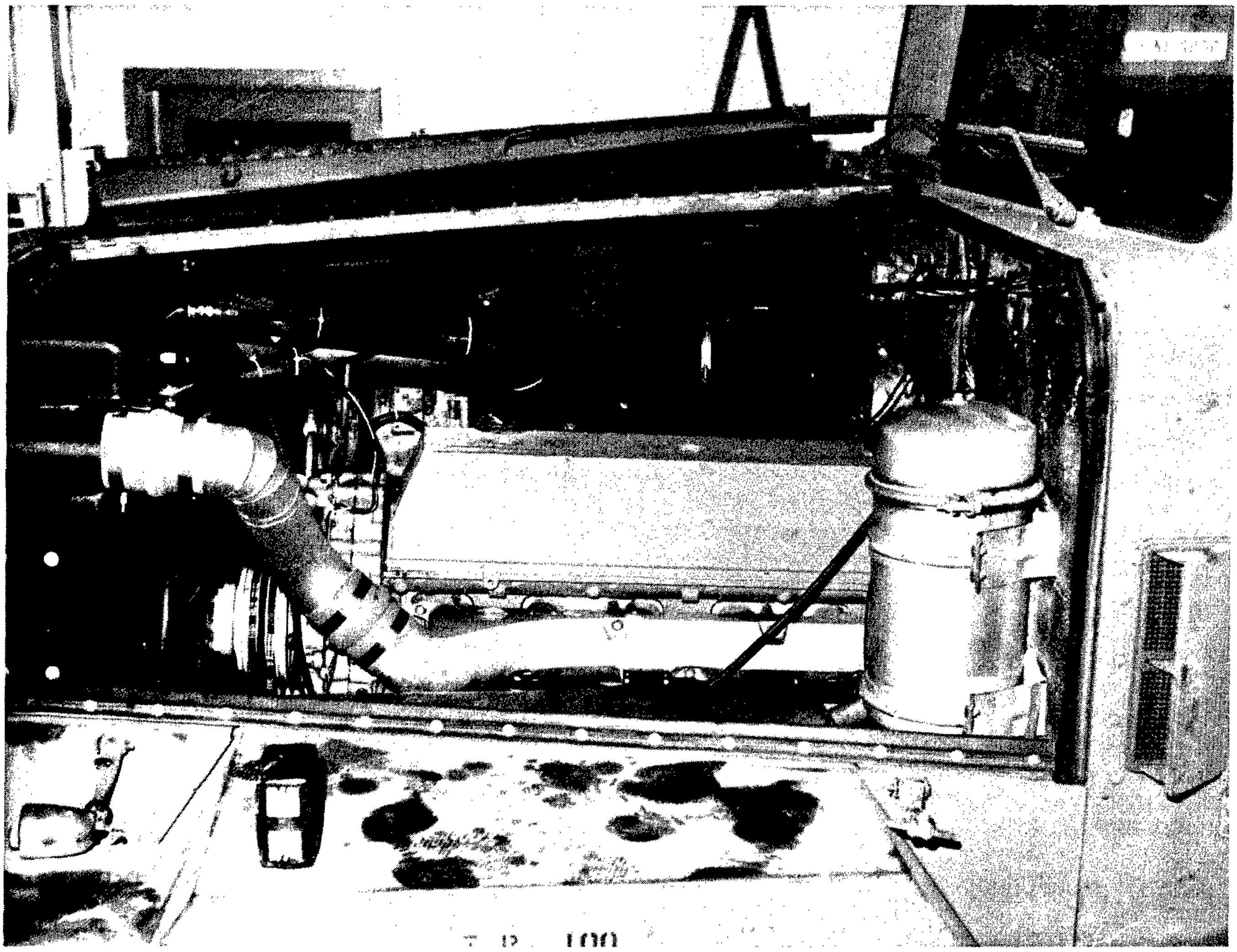

Figure 5-6. Charge Air Duct From Cooler To Engine Intake

5.3.1.4 Hoses

New hoses for the radiator, power steering, charge air, and transmission cooling systems were fabricated, rerouted and supported to minimize interference and wear from any contact.

5.3.2 Engine Mounts

The front engine mount was reworked and new mounting pad insulators were installed. New engine rear mounts were fabricated and installed.

5.3.3 Intake and Exhaust

The air intake system was modified to incorporate the engine change and the addition of the engine air-to-air cooler. The exhaust system was altered to accommodate the new engine.

5.3.4 Axles

Spacers for the front axle were fabricated and installed to prevent steering tie rod and engine oil pan contact.

5.3.5 Propeller Shaft

A new propeller shaft was fabricated and installed to connect the new transmission to the existing tandem axles.

5.3.6 Front End Rework

Due to the cooling system changes reported in paragraph 5.3.1, the following rework was required:

- Installed new radiator mounting brackets.
- Modified and moved radiator grille forward one inch to provide room for engine air-to-air cooler.
- Modified front bumper to allow forward movement of grille.
- Installed new fan shroud on radiator.
- Modified engine cowling to compensate for one inch forward movement of grille.

5.3.7 Engine Air Starter

The vehicle supplied by TACOM was already equipped with a "Pow-R-Quik" engine air starter system. This system includes an air storage tank, muffler, solenoid valve, installation kit, miscellaneous brackets and piping, and starter motor. To adapt the existing air start system to the Detroit Diesel Series 60 engine, the starter motor had to be changed. A "Pow-R-Quik" air starter, part number DS-23 RH1, was installed.

5.3.8 Miscellaneous New and Reused Components

The existing alternator, power steering pump, and fan were reused. A new electronic throttle pedal, low water sensor for the radiator, and oil fill tubes for the engine and transmission were installed. The standard M915A1 mechanical speedometer drive was used.

5.4 Electronic Controls Installation

5.4.1 Transmission

The Allison HT 755CR transmission with Allison Transmission Electronic Controls (ATEC) was installed in the vehicle.

5.4.1.1 Electrical Harness Installation

Two separate wiring harnesses are used to connect the components of the ATEC system. A cab harness connects the components most commonly found in an environmentally protected area (within the cab): the ECU, shift selector, Digital Data Link (DDL) scanner, and the necessary connections to interface with the vehicle electrical system. The second, a chassis harness, connects the ECU to the components located outside the protected area: transmission, throttle position signal unit (located in the cab) and speed sensor.

The wiring harnesses were positioned such that they were directed upward into the various components to prevent the harness from directing moisture or contaminants to the connectors. Elastomer edge guards were used when passing through sheet metal. Harnesses were secured at 200-300 mm (8-12 inches) from the various connectors and not subject to relative motion with the various components. All connectors used with the various components have a locking mechanism. The connectors were installed to attain a positive locking engagement when assembled. All wiring harnesses were routed carefully to avoid sharp bends and binding.

5.4.1.2 Vehicle Interface Installation

The ATEC system installed in the vehicle is designed for use with 12-volt, direct current, negative-ground vehicle electrical systems. Primary components of the ATEC system are connected by the cab and chassis harnesses. Various other electrical connections are required to adapt the ATEC to the vehicle electrical system. A connector is provided as part of the harness assemblies to interface with the appropriate vehicle circuits. These connections are defined in this section.

5.4.1.2.1 ATEC Electrical Power Requirements. Voltage requirements for this system are:

	12-Volt System
Minimum	10 Volts
Maximum Continuous	16 Volts
Maximum Intermittent	19 Volts

5.4.1.2.2 Wire 203 Continuous Memory Power. This portion of the harness powers the memory for diagnostic codes and throttle sensor calibration value. This memory is powered, even while the engine is shut down and the vehicle master ignition switch is off, in order for the calibration information to be saved from day to day and error codes to be saved for later readout. If power to this circuit is interrupted, the current calibration value and any stored diagnostic codes will be lost. Upon repower, the proper calibration will be established and any unresolved error codes will be regenerated by ATEC with little, if any, loss in performance. Current requirements for this memory in a 12-volt system are 10mA maximum.

5.4.1.2.3 Wire 225 or 235 Shift Selector Power. This wire powers the shift selector with 12 volts when the master ignition switch is turned on. The selector requires power (before the engine is started) to enable the neutral-start circuitry. Only one of these two wires is required for an installation. Current requirements are:

	12-Volt System
Continuous	30 mA
Peak	90 mA

5.4.1.2.4 Wire 202A and 223A ATEC ECU Power. Power for the ECU is supplied from the vehicle master ignition switch. Lengths and sizes of these two wires (and their corresponding vehicle interface wires) are chosen to assure 10 volts minimum to the ECU under all operating conditions of the vehicle electrical system. Two wires are utilized simply to provide redundancy and allow use of smaller gage cable. Power requirements vary due to operating conditions and are:

	12-Volt System
Maximum Continuous	
Neutral	2.8 Amp
In Range-Converter	3.5 Amp
In Range-Lockup	4.2 Amp
Peak During Shifts	6.0 Amp

5.4.1.2.5 Neutral Start. Wire 231 goes from OPEN to GROUND whenever the transmission is placed in neutral. This must be used with an external relay for functions requiring neutral operation; e.g., engine starting. Unlike other relays in the system, this provision can handle relays down to 30 ohms DC resistance.

5.4.1.2.6 Reverse Warning. Wire 214 goes from OPEN to GROUND whenever the transmission is placed in reverse. This must be used with an external relay for functions requiring reverse operation; e.g., backup lights and reverse warning horn. This feature is used in lieu of a reverse pressure sensor.

5.4.1.2.7 CHECK TRANSMISSION. Wire 215 goes from GROUND to OPEN whenever an alarm condition occurs in the system. This is used with an external relay to drive a dash-mounted "CHECK TRANSMISSION" light.

5.4.1.2.8 Diagnostic Mode. Wire 216A needs to be grounded by a switch mounted in the operator area to place the ATEC into the diagnostic mode. This will enable diagnostic codes to be identified by the number of flashes of the "CHECK TRANSMISSION" light.

5.4.1.2.9 System Grounds. Wires 208 and 209, ECU grounds, are connected to the negative side of the vehicle batteries. Wire 201, ECU electro-magnetic shielding ground, runs directly out of the J2-ECU connector and must be grounded to the vehicle chassis at that point. Wire 234 and wire 230, selector-lamp ground, are connected to the vehicle ground.

5.4.1.3 Electronic Control Unit (ECU)

The ECU was mounted inside the M915 vehicle cab on the back of the driver's seat pedestal which is an environmentally protected area. The ECU was mounted such that the two connectors were positioned horizontally. Clearance, accessibility, and slack were allowed for harness installation/removal without dismounting the ECU. The ECU location also provided easy removal for service or replacement. The mounting also provided a metal structure to help absorb its approximately 36 watts of continuously generated heat; thereby increasing the ECU life.

5.4.1.4 Shift Selector

The shift selector is a push-button type utilizing 3/4-inch square membrane push-button switches with backlighting controlled from the instrument panel dimmer. This component is totally electronic with no moving parts. The face of the selector is mounted a minimum of 20 degrees from flat. The shift selector is provided with four holes for mounting to an instrument panel or pedestal. The selector was mounted to a pedestal and the pedestal was then mounted to the M915 vehicle floor with four bolts. The shift selector has a built-in "DO NOT SHIFT" light/beeper to a signal when shift selection has been impaired.

The shift selector was positioned for maximum operator comfort, viewing and accessibility at the operator's right hand beside the seat (see Figure 5-7).

The electrical harness connecting the shift selector to the ECU was routed through the center of the pedestal. Slack was provided for easy installation/removal.

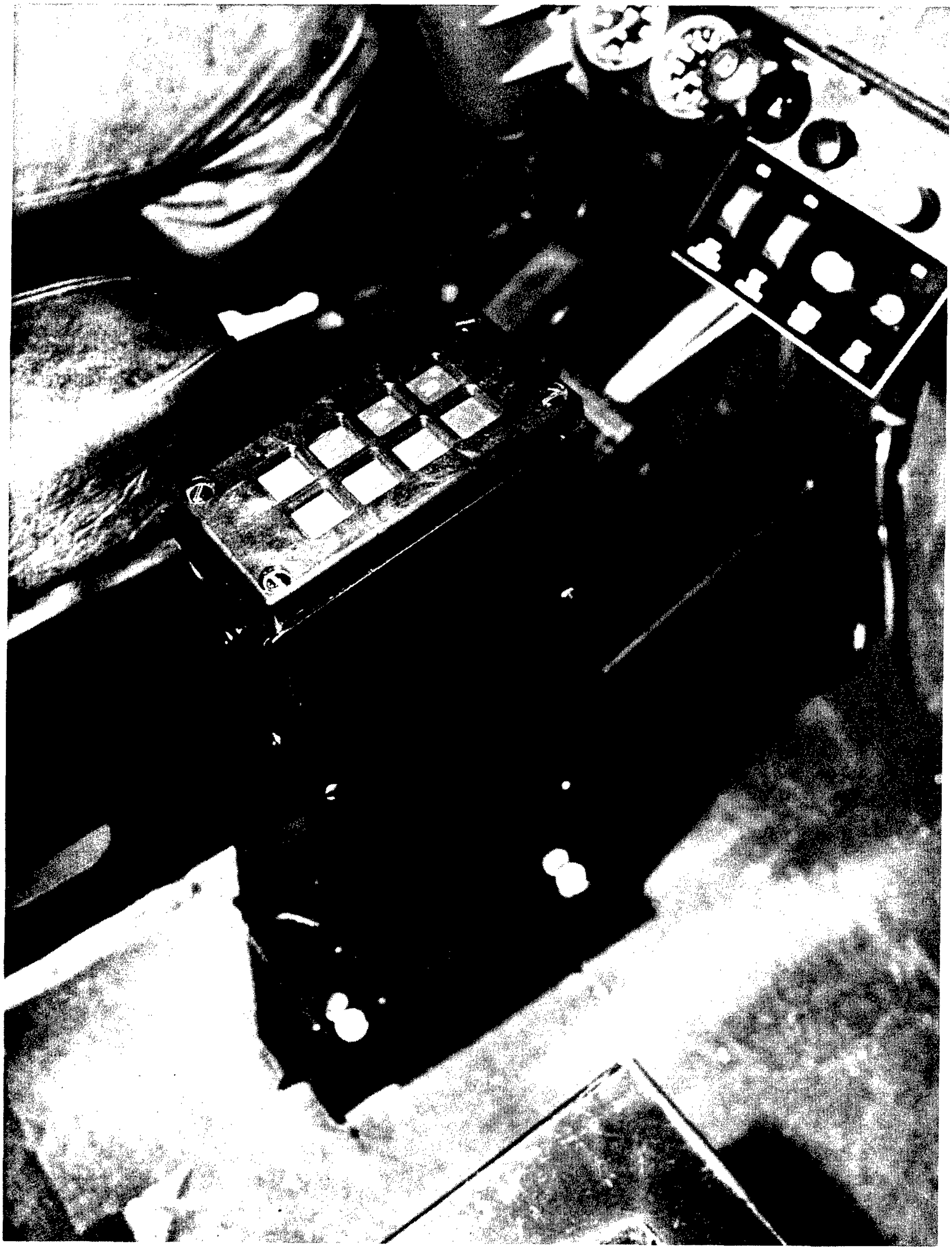

Figure 5-7. Shift Selector Installation

5.4.1.5 CHECK TRANSMISSION Light

A "CHECK TRANSMISSION" light was installed on a small add-on dash panel attached to the bottom of the dash (see Figure 5-8).

5.4.1.6 Throttle Position Signal Interface Unit

The ATEC/DDEC throttle signal interface unit to link the throttle position signal used by the DDEC system to the ECU of the ATEC system was installed. By utilizing this link, only one throttle position sensor was required for both the ATEC and DDEC systems. The throttle signal interface unit was attached to the firewall below the dash.

5.4.1.7 Display Data Line (DDL) Connector

The DDL feature is designed for use with a hand-held scanner for service functions. The diagnostic mode can be attained by the scanner when it is plugged into the DDL connector. Hence, this connector was located in the driver's area for easy access by a service technician.

5.4.1.8 Speed Sensor

A speed signal is generated from a 16-tooth gear by a magnetic speed sensor mounted on the transmission output cover. This signal represents transmission output speed which is directly related to vehicle speed. This sensor is provided in the main transmission assembly and is integral with each unit.

5.4.2 Engine - DDEC Installation

The Series 60 engine with DDEC system and the HT 755CR with ATEC were installed in the modified M915 vehicle.

5.4.2.1 Electrical Harness Installation

Three separate wiring harnesses are used to connect the components of the DDEC prototype system:

- A 16-pin connector was used to supply battery power and ground to the engine-mounted Electronic Control Module (ECM). Additionally, this connector contains the circuits that supply power from the ECM to the Electronic Unit Injector (EUI) solenoids.

- A 30-pin vehicle harness assembly was used to interface the Electronic Foot Pedal Assembly (EFPA), coolant level sensor, diagnostic connector, switched ignition feed, and "CHECK" and "STOP" engine warning lights with the engine-mounted Electronic Control Module (ECM).

- A 30-pin engine harness assembly was used to connect the engine-mounted sensors with the ECM. These sensors include the oil pressure, oil temperature, fuel temperature, turbo boost, and synchronization/timing reference sensors.

All sensor and ECM connectors used in the engine compartment utilize silicon seals and have a positive snap lock or screw thread type engagement. This ensures that the connectors are capable of withstanding the harsh environment typically encountered in the engine compartment.

Figure 5-8. CHECK TRANSMISSION Light

5.4.2.2 Power Harness

DDEC is a 12-volt, direct current, negative ground system. A separate six-wire power harness provides a direct battery connection to the ECM power and ground circuits in the 16-pin connector. ECM main run power, as well as power for the front and rear three injector solenoids, is supplied by two 20-amp fuses included in the fuse plate assembly. Dual battery power and ground circuits are used to provide redundancy and to minimize voltage drop.

5.4.2.2.1 DDEC Operating Voltages. The following are operating voltages meaured at the ECM:

- 24 to 16 volts DC - Operation for one minute with degraded accuracy. Continued operation at this level may damage the system.
- 16 to 11 volts DC - Voltage range for all normal accuracy.
- 11 to 7 volts DC - Operation with degraded accuracy.
- 7 to 0 volts DC - No damage to system. Engine may not start or run.
- 0 to -16 volts DC - When wiring is properly fused, no damage to system (fuses may blow).

Normal Accuracy Defined - Beginning of injection and fuel pulse signal are within 0.5 crank degrees of the computed value.

Degraded Accuracy Defined - Beginning of injection and fuel pulse signal are within 1.0 crank degrees of the computed value.

5.4.2.2.2 Wires 240 and 241 Continuous Battery Power. These wires supply continuous battery power for ECM main run and injector solenoids. This power is supplied while the engine is shut down and the vehicle master ignition switch is off. However, disruption of this power (battery disconnected) will not result in a loss of any previously logged error codes or affect operation of the system once power is restored. Current requirements are:

Ignition Off	10 mA
Ignition On/Engine Stopped	300 mA (min)
	500 mA (max)
With Engine Operating At:	
Idle	1.0 A
1800 RPM, Full Load	3.2 A
2100 RPM, Full Load	3.5 A

5.4.2.2.3 Wire 150 System Ground. These wires are connected directly to the negative side of the vehicle batteries.

5.4.2.3 Vehicle Harness Assembly

This harness is used to connect the various DDEC components within the vehicle cab to the engine-mounted ECM. In addition, the coolant level sensor signal wire is included as part of this harness.

5.4.2.3.1 Electronic Foot Pedal Assembly (EFPA). Wires 916 and 952, the +5V supply and sensor return, provide power and ground for the cab floor-mounted foot pedal assembly (see Figure 5-9). Wire 417 is the signal line from the throttle position sensor to the ECM.

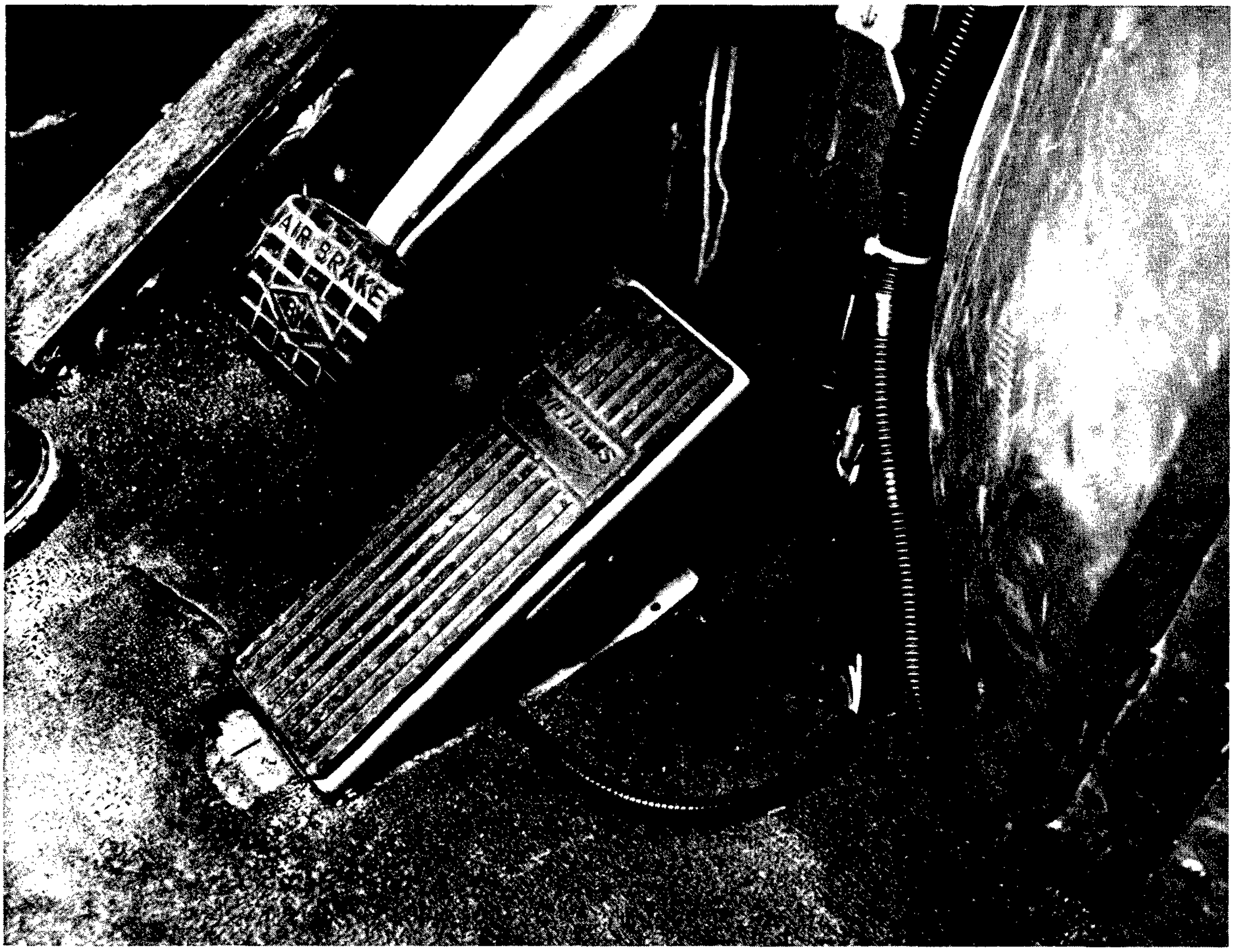

Figure 5-9. Throttle Foot Pedal Assembly

When DDEC is used in conjunction with the transmission's ATEC system, wire 908 supplies a signal representative of throttle position to the ATEC ECU. By utilizing a throttle position interface unit, only one throttle position sensor is required for a combined DDEC/ ATEC system (see Figure 5-10).

5.4.2.3.2 Coolant Level Sensor (CLS). This sensor is mounted in the radiator top tank. Its function is to indicate a low coolant level via illumination of the "CHECK" and "STOP" engine lights in the vehicle cab. This sensor provides one of three engine protection features that are standard with DDEC.

Wire 439 provides +12V ignition power for the CLS. Battery negative is used for sensor ground. Wire 115 is the sensor signal to the ECM.

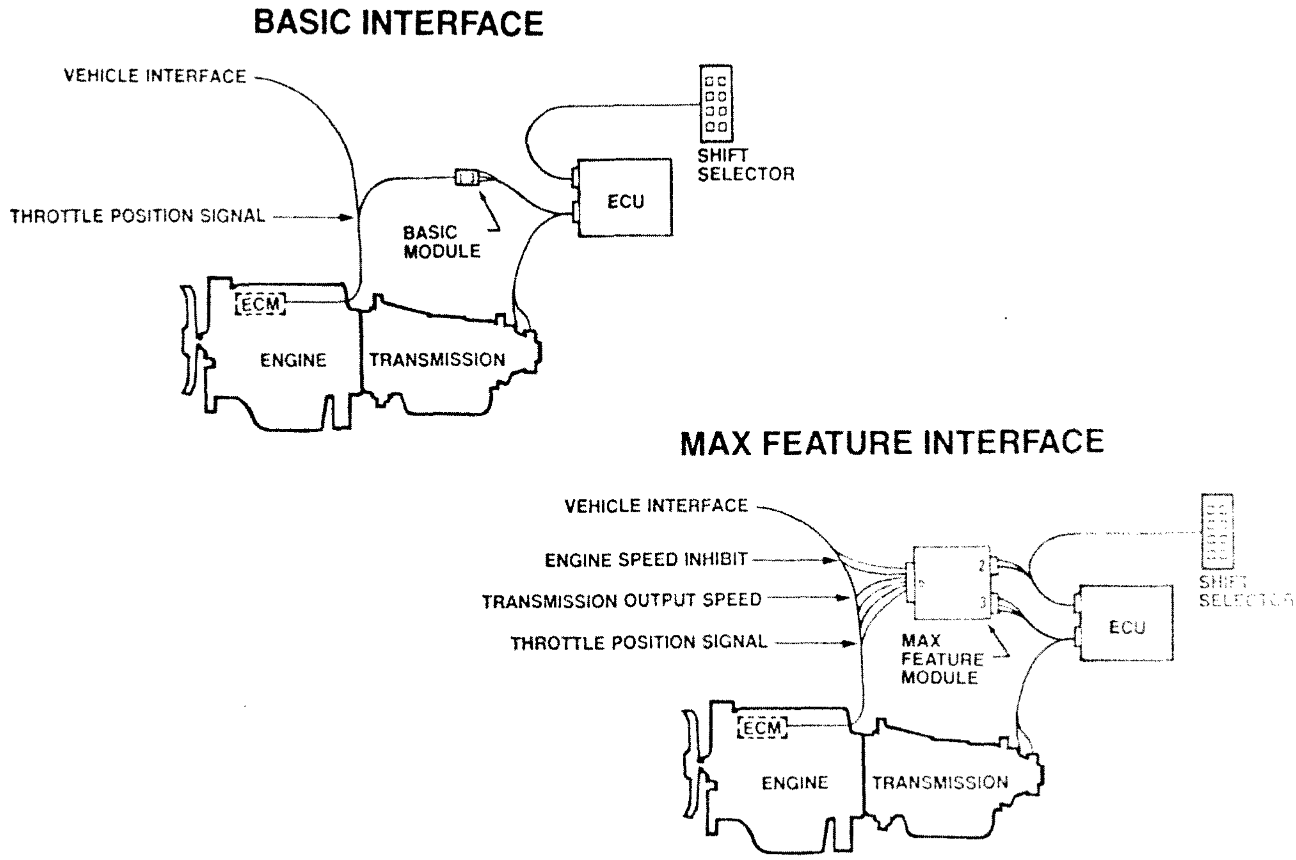

Figure 5-10. DDEC/ATEC Interface

5.4.2.3.3 Diagnostic Connector. This connector, mounted below the dash panel (see Figure 5-11), is designed for use with a hand-held diagnostic scanner for service functions. The scanner is a multi-purpose tool which can aid troubleshooting by displaying error codes and engine operating parameters.

5.4.2.3.4 Switched Ignition. Wire 439 is wired to the ignition switch to provide +12V ignition sense to the ECM as well as the coolant level sensor, "CHECK," and "STOP" engine lights.

Figure 5-11. Diagnostic Connectors For Engine and Transmission

5.4.2.3.5 CHECK ENGINE Light. "CHECK ENGINE" light was installed in the vehicle dash (see Figure 5-12). This amber (yellow) light illuminates to indicate either the presence of an error code detected by the system or an engine protection warning code. Wire 419 is the "CHECK ENGINE" light circuit to the ECM.

5.4.2.3.6 STOP ENGINE Light. A "STOP ENGINE" light was also installed in the vehicle dash (see Figure 5-12). This red-colored light illuminates if the system detects the loss of coolant, low oil pressure, or high oil temperature. Wire 509 is the "STOP ENGINE" light circuit to the ECM.

5.4.2.3.7 Diagnostic Mode. Wire 451 is grounded by a switch mounted in the operator area to place the DDEC system into the diagnostic mode. Codes can then be identified by the number of flashes of the "CHECK ENGINE" light.

5.4.2.4 Engine Harness Assembly

The factory-installed engine harness interfaces engine sensors to the ECM as part of the standard engine protection, fuel consumption, smoke control, and injector timing features of the system. Wire 416 provides the +5V power for the oil pressure and turbo boost sensors. Wire 452 provides sensor return for oil pressure, oil temperature, fuel temperature, and turbo boost sensors.

5.4.2.4.1 Oil Pressure Sensor (OPS). Wire 530 provides the signal indicating engine oil pressure. This is used as part of the standard engine protection feature of the DDEC system.

5.4.2.4.2 Oil Temperature Sensor (OTS). Wire 120 provides the signal indicating engine oil temperature. Like the coolant level and oil pressure sensors, it is used as part of the engine protection feature. In addition, it is used to enhance cold startability and white smoke control at engine start-up.

5.4.2.4.3 Fuel Temperature Sensor (FTS). Wire 472 provides the signal indicating fuel temperature. This value is used by the ECM to compensate for fuel density changes with temperature as part of the fuel consumption calculation.

5.4.2.4.4 Turbo Boost Sensor (TBS). Wire 432 provides the signal indicating turbocharger boost pressure into the intake manifold of the engine. Based on input from this sensor to the ECM, engine fueling during accelerations is adjusted to minimize black exhaust smoke.

5.4.2.4.5 Synchronization Reference Sensor (SRS). This magnetic sensor provides a once per engine revolution signal to the ECM upon engine start-up to establish the correct injector firing order. Wires 111 and 112 provide this signal.

5.4.2.4.6 Timing Reference Sensor (TRS). This magnetic sensor provides a once per cylinder indication to the ECM to establish injector timing and fueling as a function of engine speed, throttle position, turbo boost, and oil temperature. Wires 109 and 110 provide this signal.

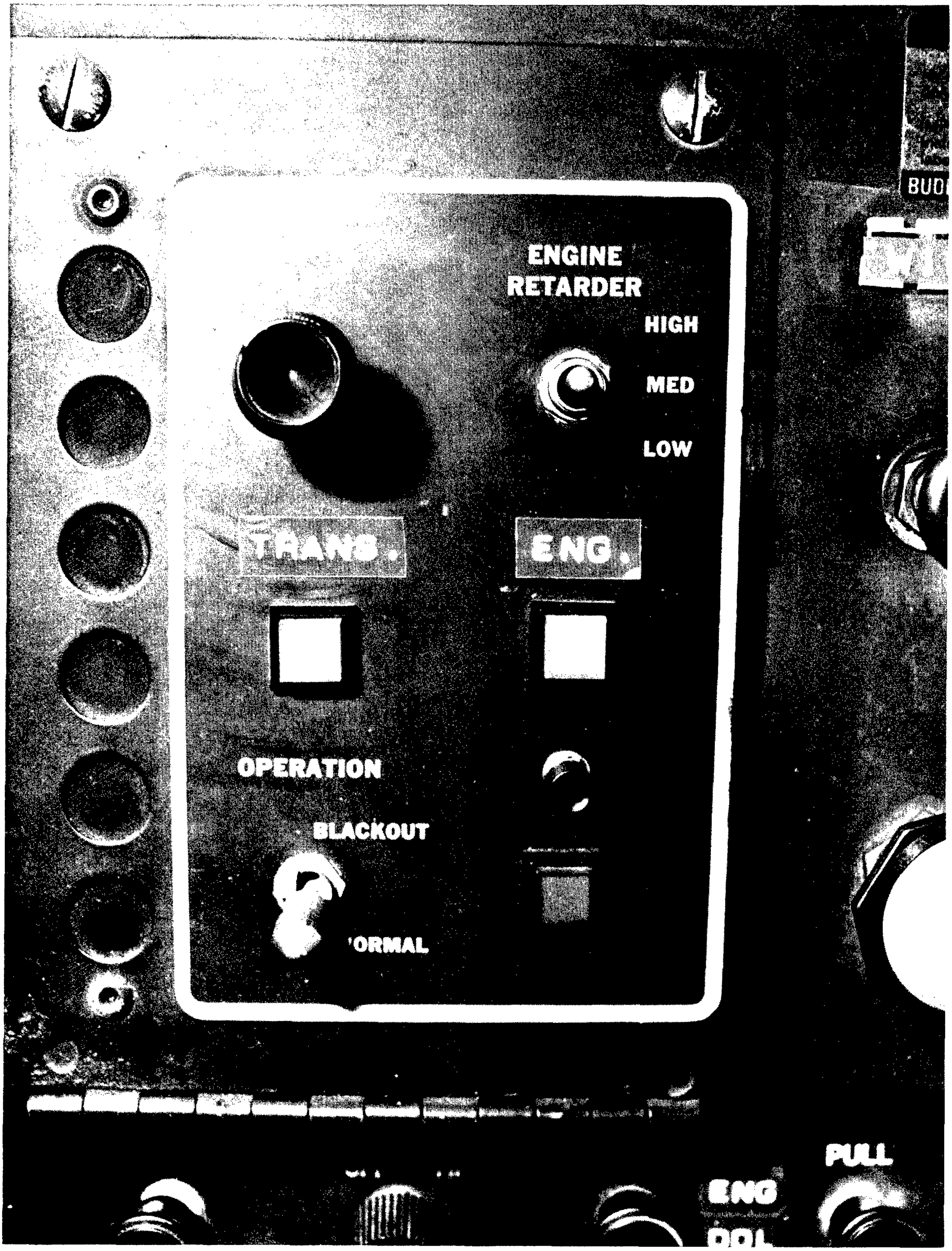

Figure 5-12. CHECK ENGINE and STOP ENGINE Lights

5.5 Performance Testing

5.5.1 General

Per Section C.2 of the contract, various vehicle performance tests were required. The form of these tests were agreed upon in a 2 June 1986 letter from ATD to TACOM and confirmed in a 21 July 1986 letter from TACOM to ATD (see Appendix A). The tests to be completed were a shakedown test, stabilized speed on grade, acceleration, panic brake stop, and engine air starter tests. The Contracting Officer's Technical Representative from TACOM observed all tests with the exception of the shakedown. The vehicle loading for performance testing was as follows:

Weight on Steering Axle	=	11,610 lbs
Weight on Driving Tandem Axle	=	35,040 lbs
Weight on Trailer Tandem Axle	=	33,670 lbs
Gross Combination Weight	=	80,320 lbs

5.5.2 Shakedown Test

The shakedown test was performed at General Motors Proving Grounds (GMPG) at Milford, Michigan. Sufficient mileage was run to verify proper operation of all modified systems. The test included operation over the entire operating range of the Detroit Diesel Series 60 engine and the Allison HT 755CR transmission. During the shakedown test, it was discovered the windshield wipers did not work. It was also determined the service brakes would self-apply at random intervals (occurred twice in approximately 300 miles of testing), slowly applying the brakes to the vehicle. These conditions were reported to TACOM and assumed to have been fixed at Fort Campbell, Kentucky, prior to troop evaluation.

5.5.3 Stabilized Speed on Grade

The loaded vehicle was operated on grades of 16%, 7.2%, and 4.4% to determine maximum stabilized speeds. Those speeds recorded are as follows:

On 16% Grade:	5.9 MPH (9.5 Km/Hr)
On 7.2% Grade:	14.3 MPH (23.0 Km/Hr)
On 4.4% Grade:	26.1 MPH (42.0 Km/Hr)

5.5.4 Acceleration Tests

The loaded vehicle was operated on the military straightaway at GMPG to determine elapsed time from zero miles per hour to 20 MPH, 30 MPH, 50 MPH, and vehicle top speed. Each elapsed time was measured on a separate acceleration run. The vehicle top speed was recorded as 62 MPH (99.8 Km/Hr) with the engine operating on the governor droop. The results of the acceleration test were as follows:

0 to 20 MPH (32 Km/Hr):	12.3 Seconds
0 to 30 MPH (48 Km/Hr):	21.4 Seconds
0 to 50 MPH (80 Km/Hr):	56.5 Seconds
0 to 62 MPH (99.8 Km/Hr):	106.8 Seconds

5.5.5 Panic Brake Stops

Panic brake stops were performed from various vehicle speeds to zero miles per hour to determine if engine stall would occur. For safety purposes and to allow quicker zeroing of the driveline speed, the tests were performed with the tractor only (no trailer). The panic brake stops were initiated on separate runs from 10 MPH (16 Km/Hr), 20 MPH (32 Km/Hr), 30 MPH (48 Km/Hr), and 40 MPH (64 Km/Hr). No engine stall occurred on any of the runs.

5.5.6 Engine Air Starter Tests

To obtain some data on the capabilities of an engine air starter, two tests were performed. In the first test, the tractor was operated until the air starting system was fully charged. The engine was then shut down. With the engine prevented from starting but free to crank, the starter motor was engaged and elapsed time and cranking RPM was recorded. The results were as follows:

Cranking Speed (in RPM)	Elapsed (in Seconds)
214	1.0
288	1.5
242	2.0
267	2.5
255	3.0
135	3.5
24	4.0
7	4.5
1.75	5.0
0.33	5.5
0.0	6.0
0.0	6.5
0.0	7.0

In the second test, the tractor was operated until the air starter system was fully charged then shut down. This test was to determine how many times the engine could be started with an initial fully charged system and only ten seconds of engine operation at idle speed between engine start attempts. The installed air start system, operated as described above, was capable of starting the engine two times. (See Appendix A for confirmation of all test results.)

5.6 Performance Comparison

5.6.1 Actual vs Predicted Performance

Allison Transmission Division computerized performance prediction program, SCAAN (System for Computerized Application ANalysis), was used to predict the performance of the test vehicle. The predicted performance covers the entire vehicle operating band and is compared to the actual test results in Figures 5-13 and 5-14. The computer-modeled performance correlates fairly well with the actual test results. The small differences could be attributed to slight differences in actual vs model dynamic tire size, rolling resistance, wind resistance, etc. Even with the small variations, the computer prediction can be confidently used to judge the vehicle's performance for speeds other than those tested.

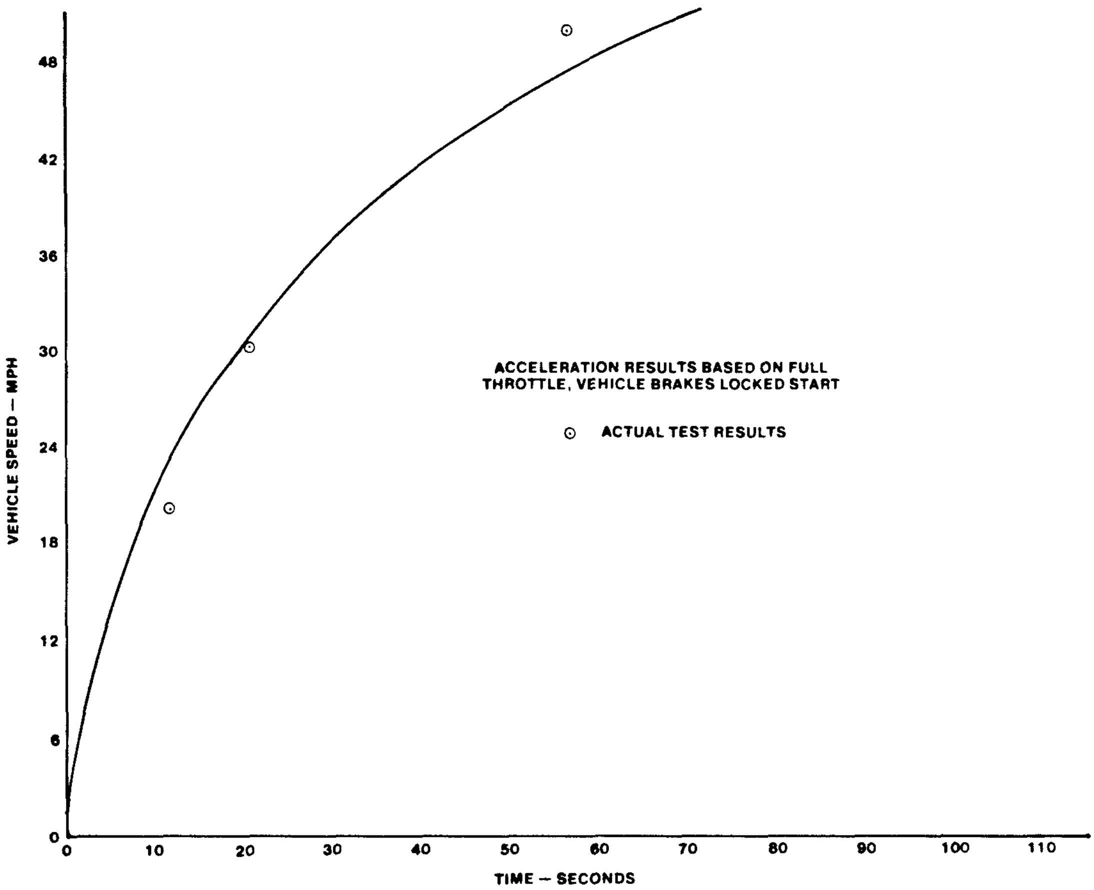

Figure 5-13. Vehicle Acceleration (Predicted vs. Actual)

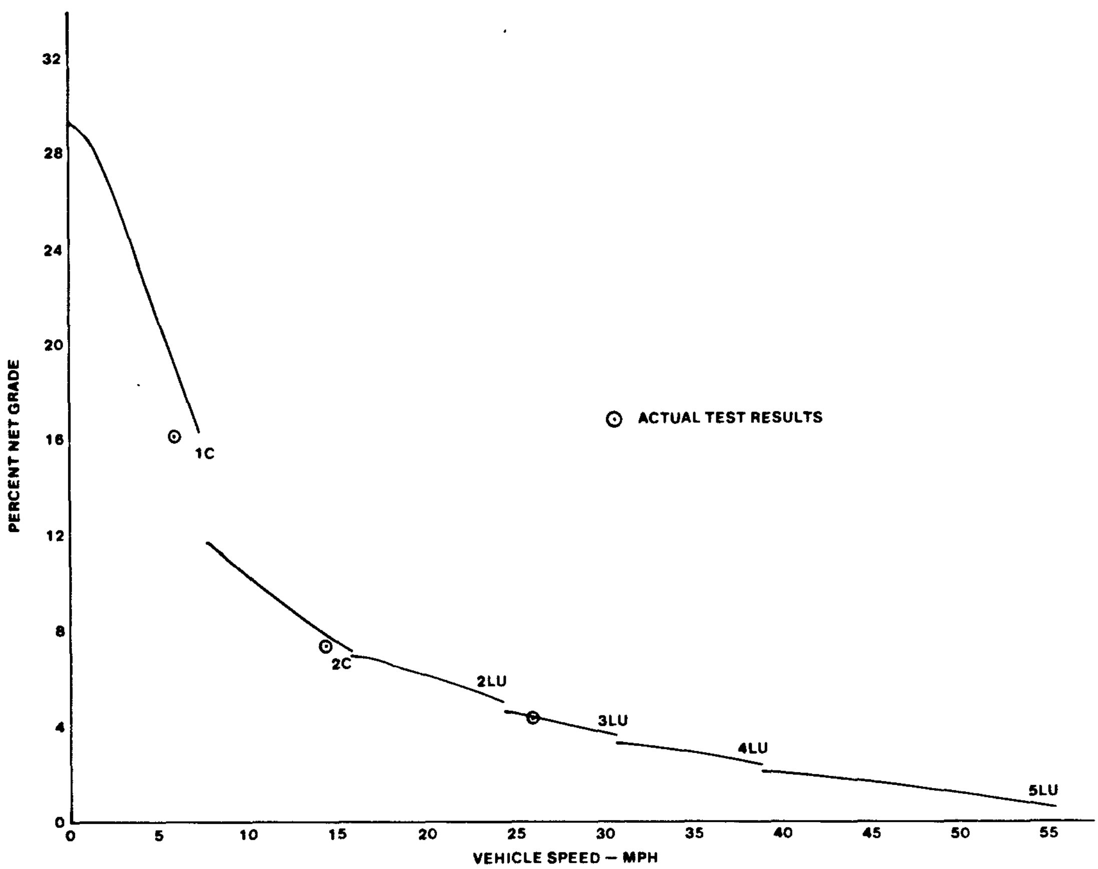

Figure 5-14. Vehicle Gradeability

5.6.2 M915A1 vs ATEC/DDEC Demonstrator Performance

There was no baseline vehicle available for performance comparison. To allow the reader a point of reference, Allison's SCAAN computer performance prediction program has been employed. The same vehicle computer model is used for the "demonstrator" and the M915A1 with the exception of engine and transmission. The weight of each model has been left at the test weight of 80,320 lbs. The predicted performances of both vehicles are provided in Figures 5-15, 5-16, and 5-17. Tabular data on the performance prediction for each vehicle is located in Appendix B.

5.7 Demonstrations and Evaluations

5.7.1 General

As part of the contract, the M915 ATEC/DDEC test vehicle was to be demonstrated for the Government. This was accomplished with one demonstration at the General Motors Proving Grounds (GMPG) in Milford, Michigan, and another at the Tank Automotive Command (TACOM) in Warren, Michigan. Also at the request of TACOM, the test vehicle was made available for troop evaluation at Fort Campbell, Kentucky, and high altitude burst electro-magnetic pulse testing at White Sands Missile Range, New Mexico.

5.7.2 GMPG Demonstration

The demonstration at GMPG took place on 9 July 1986 and was limited to no more than 15 attendees from TACOM. The program consisted of a verbal/viewgraph presentation, electronic controls demonstration, and vehicle ride and drive.

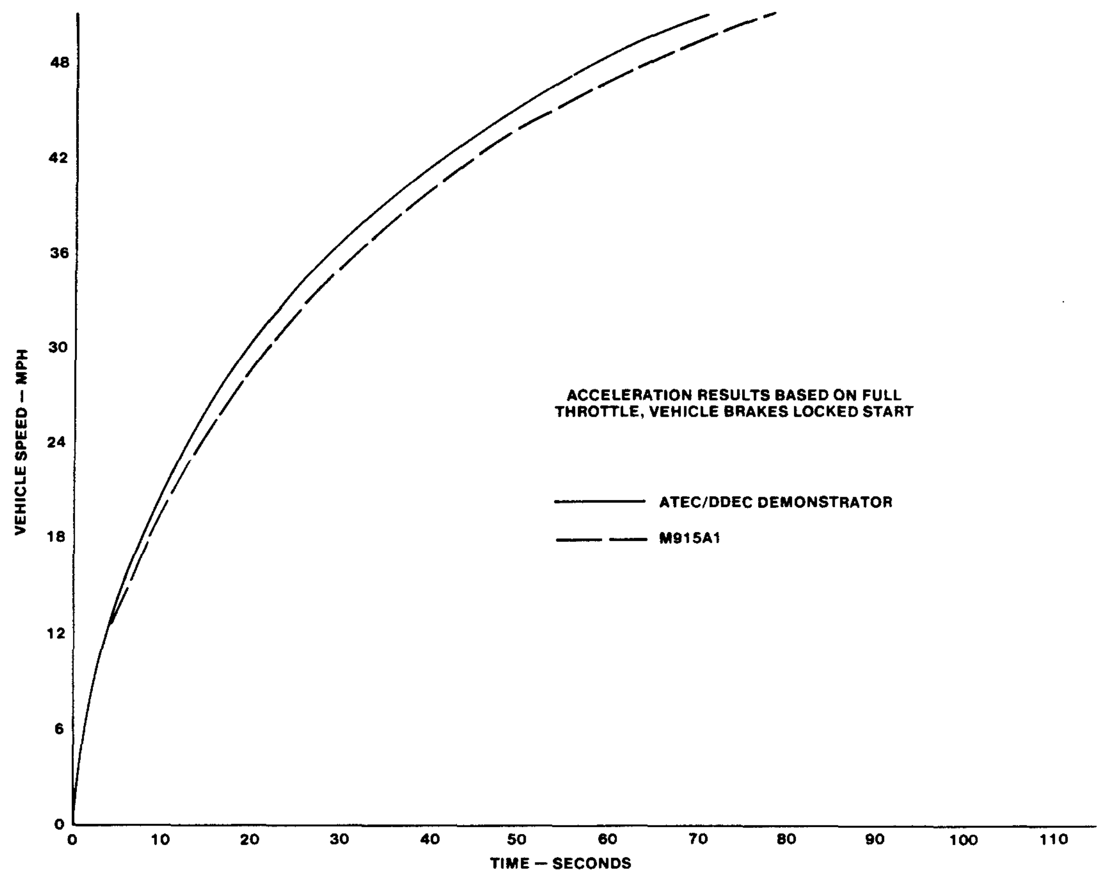

Figure 5-15. Vehicle Acceleration

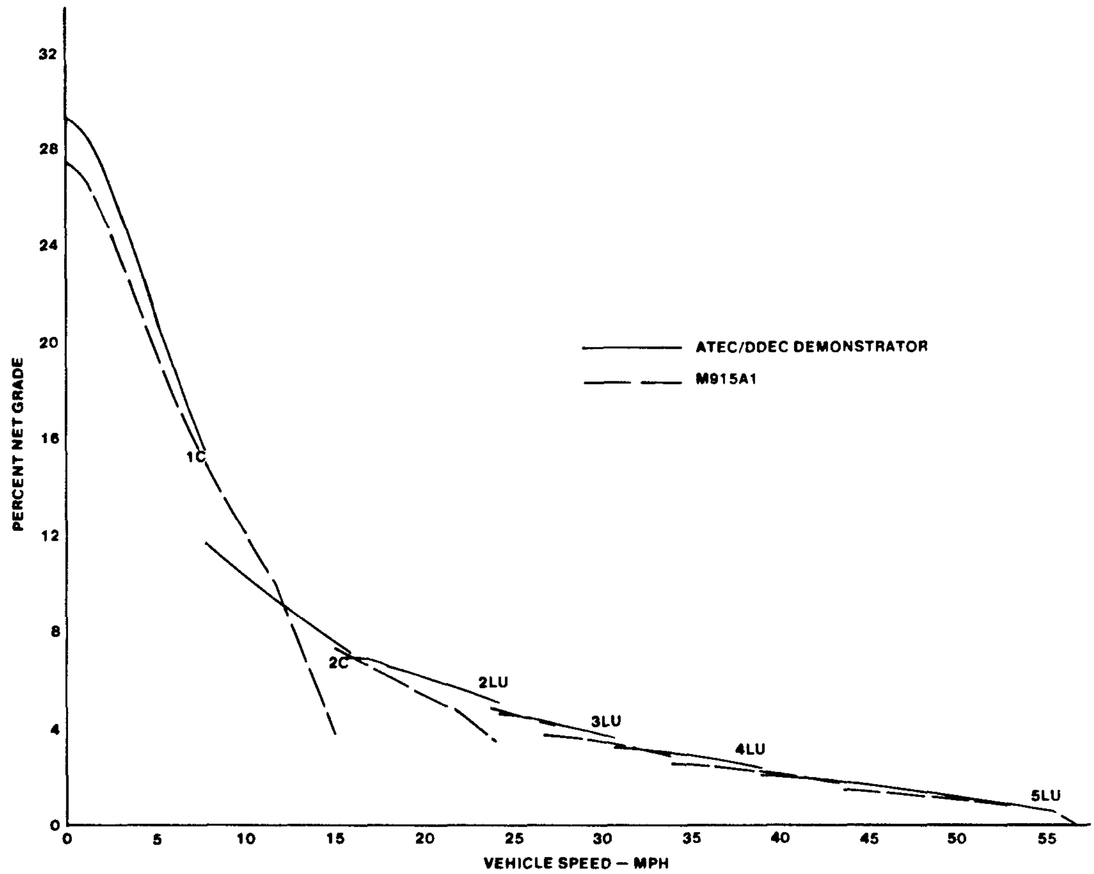

Figure 5-16. Vehicle Gradeability

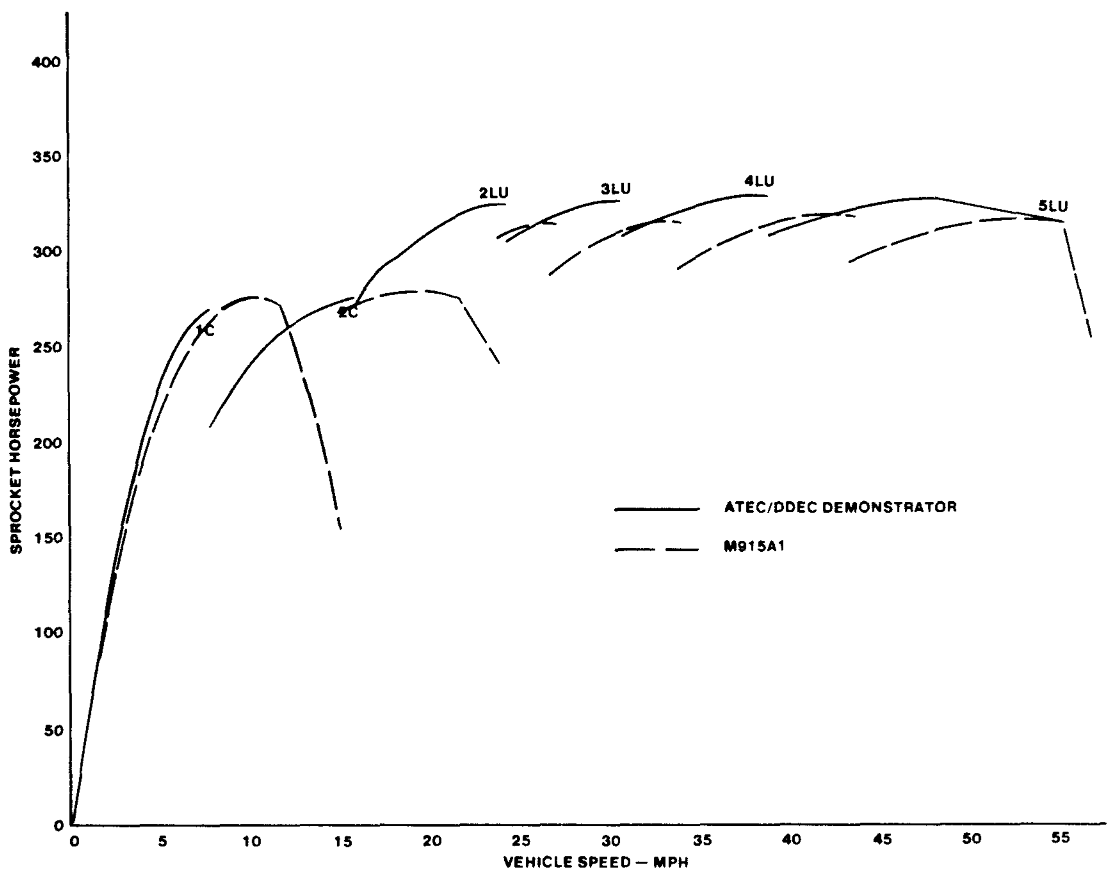

Figure 5-17. Vehicle Wheel Horsepower

5.7.2.1 Electronic Controls Demonstration

During the static display of the test vehicle and with the help of the ATEC/DDEC simulator board, the following advantages of electronic controls were demonstrated and explained (see Figures 5-18 and 5-19).

Figure 5-18. ATEC/DDEC Simulator Board

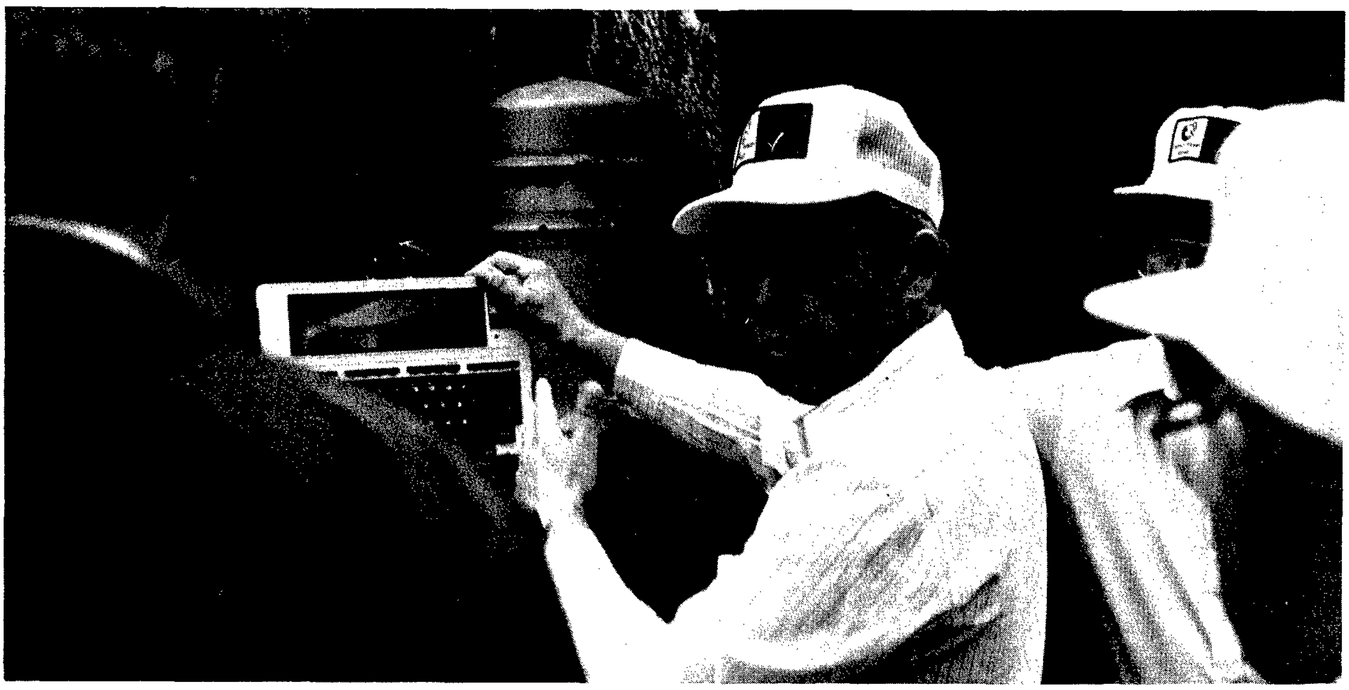

Figure 5-19. Engine Diagnostics Demonstration

- Engine diagnostics.
- Transmission diagnostics.
- Engine start-up smoke elimination.
- Engine idle time limiter.
- Transmission protection sensing and alarms.
- Engine protection sensing and alarms.
- Hand throttle capabilities.
- Transmission neutral-to-range shift inhibit with parking brake on.
- Detailed display, demonstration, and explanation of individual electronic components with simulator board.

5.7.2.2 Ride and Drive Demonstration

The M915 demonstrator vehicle, as well as two other ATD electronically-controlled vehicles, were made available for the participants to either ride or drive (see Figure 5-20). These vehicles were:

- 1985 GMC dump truck with a Detroit Diesel 6-71 engine and an Allison HTB 755DR transmission (ATEC).
- 1986 Kenworth linehaul tractor with a Detroit Diesel 8V92TA engine (DDEC) and an Allison HTB 755CR transmission (ATEC).

Figure 5-20. "Ride and Drive" Vehicles

The electronic controls advantages demonstrated in the M915 test vehicle (see Figure 5-21) were:

- Two engine power curves in one engine.
- Two transmission shift schedules in one transmission.
- Engine overspeed protection.
- "Limp Home" capability.

Transmission retarder capabilities were demonstrated in both ATD commercial vehicles. The ability of the transmission and engine electronic controls to work together for vehicle cruise control was demonstrated in the Kenworth linehaul tractor.

Figure 5-21. M915 ATEC/DDEC Demonstrator

5.7.3 TACOM Demonstration

The demonstration at the Tank Automotive Command in Warren, Michigan, took place on 11 August 1986. The program included verbal/viewgraph presentations, test vehicle static display, ATEC/DDEC operating simulation with the simulator board, and a question and answer period.

5.7.4 Troop Evaluation

At TACOM's request, Allison Transmission and Detroit Diesel provided technical support for the demonstrator vehicle while it was operated at Fort Campbell, Kentucky, for troop evaluation. In late July 1987, a briefing was presented covering performance characteristics, operating instructions, daily maintenance, diagnostic procedures, and non-modified vehicle system concerns. As of the beginning of August 1988, the demonstrator vehicle had been successfully operated for approximately seven hundred miles without engine or transmission incident.

5.7.5 High Altitude Burst Electro-Magnetic Pulse Test Evaluation

The M915 ATEC/DDEC demonstrator vehicle was subjected to high altitude burst electromagnetic pulse (HABEMP) testing at White Sands Missile Range, New Mexico, from September 1986 to July 1987 (see Figures 5-22, 5-23 and 5-24). A discussion of the results of that testing is covered under separate Appendix to this report.

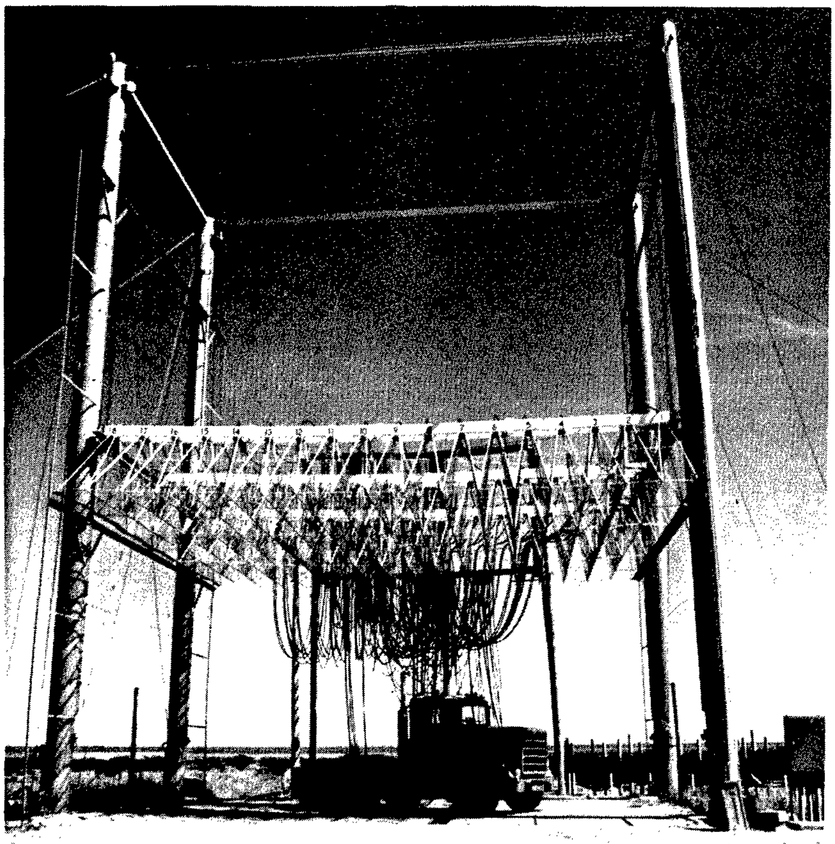

Figure 5-22. EMP Test Setup

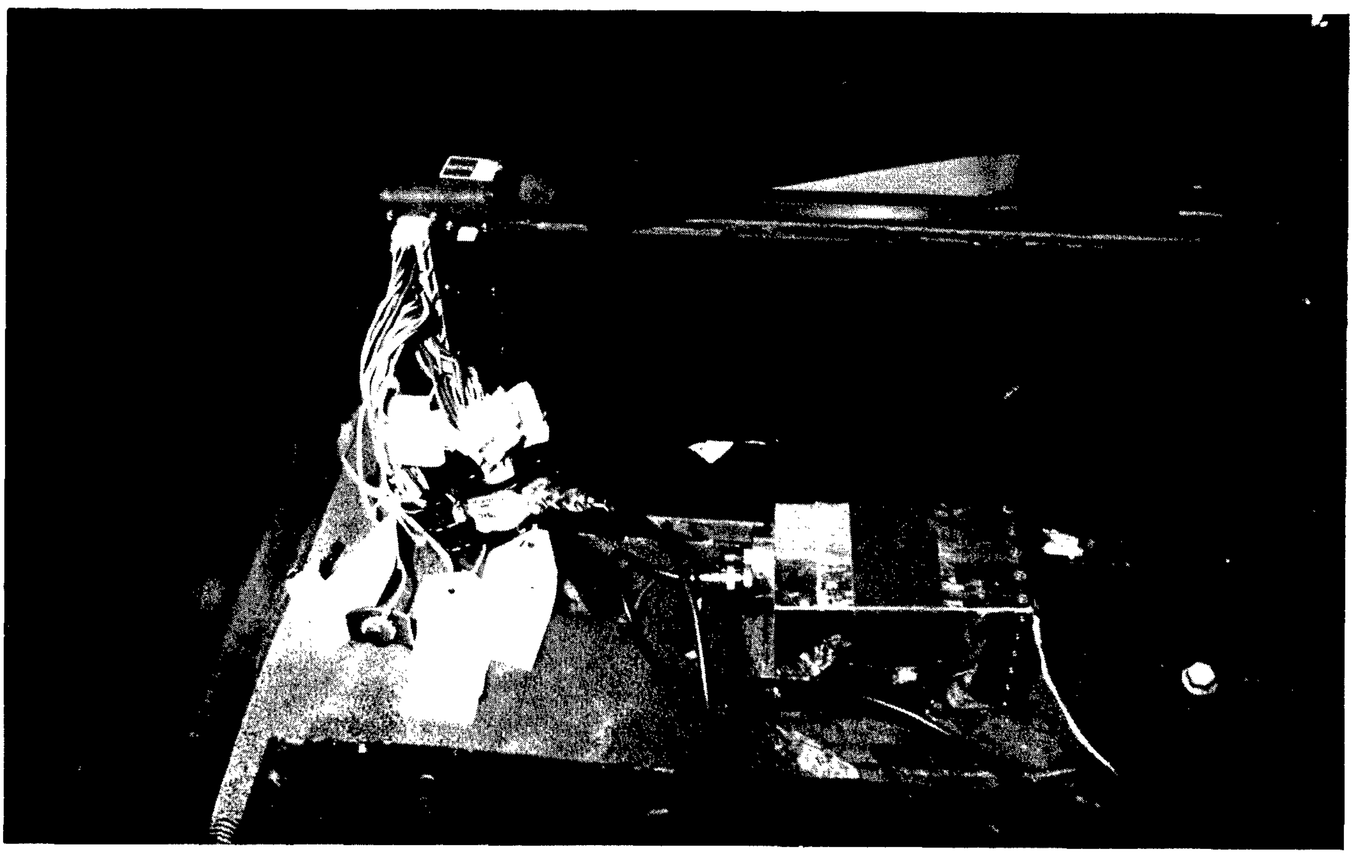

Figure 5-23. ECU Installation and Instrumentation

Figure 5-24. EMP Instrumentation

APPENDIX A

Detroit Diesel Allison
Division of General Motors Corporation

Indianapolis Operations

P O Box 894
Indianapolis, Indiana 46206-0894
Phone (317) 242-5000
TWX 810-341-3120
TELEX 276411 GM COMM IND

June 2, 1986

Commander
U.S. Army Tank-Automotive Command
Attn: AMSTA-RGT (Roman Rudnitsky)
28251 Van Dyke Avenue
Warren, MI 48397-5000

Subject: M915 Demonstrator Program
Contract DAAE07-85-C-R078
Performance Testing

Dear Roman:

Per the requirements of Section C.2 of the subject contract, the following test plan is proposed:

1) Shakedown Test - The test vehicle loaded to approximately 80,000 pounds GCW will be operated on the "Truck Test Loop" at G.M. Proving Grounds, Milford, Michigan. Sufficient mileage will be run to assure proper operation of all modified systems. This test shall also include operation over the entire operating range of the Series 60 Engine and the HT-755CR transmission. A functional checkout shall be made of all safety systems such as brakes, air lines, warning devices, lights, etc.

2) Performance Test - The test vehicle loaded to approximately 80,000 pounds GCW will be operated on 16%, 7.2% and 4.4% grades to determine maximum stabilized speeds. The vehicle will also undergo acceleration tests of 0 Km/Hr to 32, 48, 80 Km/Hr and maximum speed on the paved "Military Straightaway".

The above tests will be scheduled and run at Detroit Diesel Allison's convenience. The Contracting Officer's Technical Representative can be notified 24 hours prior to the tests if so desired.

Please provide your approval of the above prior to June 20, 1986. If you have any questions, please don't hesitate to call.

Sincerely,

B. E. Adams

B. E. Adams
Military Applications

1392w/bjw
c: L. K. Johnson, P. L. Perdue, K. D. Struthers, J. J. Monette, C. W. Burley

EA/M915-17

DEPARTMENT OF THE ARMY
UNITED STATES ARMY TANK-AUTOMOTIVE COMMAND
WARREN, MICHIGAN 48397-5000

REPLY TO
ATTENTION OF

July 21, 1986

AMSTA-RGT

Mr. B. E. Adams
Detroit Diesel Allison Division
General Motors Corporation
Post Office Box 894, Speed Code E-11
Indianapolis, Indiana 48206-0894

Dear Mr. Adams:

The proposed test plan, submitted in your letter of July 2, 1986, has been reviewed.

As we understand it, the performance test will include the loaded vehicle that will be operated on 16, 7.2, and 4.9 percent grades to determine the stabilized speeds. The vehicle will also undergo acceleration test of 0 kilometers per hour to 32, 48, and 80 kilometers per hour, and maximum speed on paved "Military Straightway".

We would like to include panic brake stops from 64, 48, 32, and 16 kilometers per hour. The vehicle should be bobtail (no trailer).

Please make attempt to obtain history of starter cranking revolutions per minute (rpm) versus time without engine starting and running. For second portion of test, start and run engine for ten seconds and shut down. Start and run engine again for 10 seconds, and keep operating until the starter will not start the engine anymore.

We are also asking that the Contracting Officer's Technical Representative be notified minimum of 24 hours prior to the tests.

As long as the above criteria are observed, the approval for the above tests is given.

Please rescind letter of July 17, 1986.

If you have any questions, please contact the undersigned at (313) 574-5189.

Sincerely,

Roman G. Rudnitsky

Roman G. Rudnitsky
Contracting Officer's
Technical Representative

DEPARTMENT OF THE ARMY
UNITED STATES ARMY TANK-AUTOMOTIVE COMMAND
WARREN, MICHIGAN 48397-5000

REPLY TO
ATTENTION OF

April 6, 1987

AMSTA-RGT

Mr. B.E. Adams
Military Applications
Detroit Diesel Allison
P.O. Box 894
Indianapolis, Indiana 46206-0894

Dear Mr. Adams:

With reference to your letter of March 31, 1987, enclosed are the original signed papers for the M915 Demonstrator Contract DDAE07-85-C-R078 Performance Test.

If you should have any questions regarding the enclosed, please call Mr. Ted Zimmerman at (313) 574-5158.

Sincerely,

Peter C. Manning
Chief, Transmission and
Integration Branch

Enclosures

M915 DEMONSTRATOR
CONTRACT DDAE07-85-C-R078
PERFORMANCE TEST

STARTER CRANKING

1) Cranking Speed @

1.0	Second:	214	RPM
1.5	Seconds:	288	RPM
2.0	Seconds:	242	RPM
2.5	Seconds:	267	RPM
3.0	Seconds:	255	RPM
3.5	Seconds:	135	RPM
4.0	Seconds:	24	RPM
4.5	Seconds:	7	RPM
5.0	Seconds:	1.75	RPM
5.5	Seconds:	0.33	RPM
6.0	Seconds:	0	RPM
6.5	Seconds:	0	RPM
7.0	Seconds:	0	RPM
7.5	Seconds:	0	RPM
8.0	Seconds:	0	RPM
8.5	Seconds:	0	RPM
9.0	Seconds:	0	RPM
9.5	Seconds:	0	RPM
10.0	Seconds:	0	RPM

2) With the starter air reservoir fully charged, how many starts of the engine can be accomplished if the engine is allowed to run only 10 seconds after starting? 2 Times

B. E. Adams	3-30-87	for Roman Rudnitsky	4/3/87
B. E. Adams Military Applications Detroit Diesel Allison	Date	Roman Rudnitsky Contract Tech. Representative U.S. Army TACOM	Date

1557w/bjw

M915 DEMONSTRATOR
CONTRACT DDAE07-85-C-R078
PERFORMANCE TEST

STABILIZED SPEED ON GRADE

1) On 16% Grade: 5.9 MPH 9.5 Km/Hr
2) On 7.2% Grade: 14.3 MPH 23.0 Km/Hr
3) On 4.4% Grade: 26.1 MPH 42.0 Km/Hr

ACCELERATION TESTS

1) 0 to 32 Km/Hr (20 MPH): 12.3 Seconds
2) 0 to 48 Km/Hr (30 MPH): 21.4 Seconds
3) 0 to 80 Km/Hr (50 MPH): 56.5 Seconds
4) 0 to Top Speed: 62 MPH 99.8 Km/Hr 106.8 Seconds

PANIC BRAKE STOP: (All Stops from Full Throttle Condition)

1) From 16. Km/Hr (10 MPH): Did Not Stall
2) From 32 Km/Hr (20 MPH): Did Not Stall
3) From 48 Km/Hr (30 MPH): Did Not Stall
4) From 64 Km/Hr (40 MPH): Did Not Stall

B. E. Adams 3-30-87
B. E. Adams
Military Applications
Detroit Diesel Allison
Date

for Ted R. [signature] 4/3/87
Roman Rudnitsky
Contract Tech. Representative
U.S. Army TACOM
Date

1557w/bjw

M915 DEMONSTRATOR
CONTRACT DDAE07-85-C-R078
PERFORMANCE TEST

VEHICLE DESCRIPTION

MODEL	:	M915 LINEHAUL TRACTOR
VIN	:	OT 3814-45-10436
REGISTRATION NO.	:	CF 8179
ENGINE MODEL	:	SERIES 60C1 400 GHP @ 2100 RPM
ENGINE S/N	:	6H641
TRANSMISSION MODEL	:	HT-755CR
TRANSMISSION S/N	:	2510096622

VEHICLE TEST WEIGHT

STEERING AXLE	:	5,166 Kg (11,610 LBS.)
DRIVE TANDEM AXLES	:	15,804 Kg (35,040 LBS.)
TRAILER TANDEM AXLES	:	15,272 Kg (33,670 LBS.)
GROSS COMBINED WEIGHT	:	36,432 Kg (80,320 LBS.)

1557w/bjw

APPENDIX B

```
SCAAN No 212910
date:  9/ 2/88,   2:18pm edt
tm001127, ADAMS
REJECTED APPLICATION

              ALLISON TRANSMISSION DIV
             SCAAN Application Information
             ============================

VEHICLE:  MILITARY WHEELED VEHICLE-SUPPORT
          TACOM PROPULSION LAB. M915 ATEC/DDEC DEMONSTRATION PROG.
    7011  vocation library file number
  80320.  lbs. gross combination weight
  35044.  lbs. weight on drive wheels ( 43.6 percent)
  19.657  in. radius, wheel-  bias tires (ATD rolling resist)
  513.00  wheel rev/mile
      18  total tires in contact with road
   4.440  driveline reduction ratio, total
          driveline: propeller shaft, tandem axle
   90.00  % driveline efficiency
 (efficiency value responsibility: ADAMS)
  136.41  lb.ft.sec.2 driveline equivalent inertia
   0.700  traction limit coefficient
  1.4000  road surface factor
   13.50  x  8.00 ft. vehicle height x width
  0.7500  air resistance coefficient
 DIESEL ENGINE:  DDC SERIES 60 400 GHP @ 2100 RPM (E46067321)
  (engine data responsibility: ADAMS)
  (NOTE:  ENGINE RATING/VOCATION COMPATIBILITY
   SUBJECT TO ENGINE MFGRS. REVIEW)
   775.0  in3 engine displacement
 997615   engine library file number
   400.0  gross horsepower at 2100. rpm
  deductions- (hp. at 2100. rpm)
    28.0  hp fan (clutch engaged)
     0.0  hp fan (clutch disengaged)
     2.0  hp alternator/generator
     2.0  hp air compressor
     2.0  hp steer pump
   366.0 net horsepower     2100. rpm
    eng rpm       1100. 1200. 1400. 1600. 1800. 1900. 2000. 2100. 2250.
    entered hp    290.0 320.0 355.0 382.0 400.0 400.0 400.0 400.0   0.0
    net hp        281.9 310.5 342.0 364.6 376.9 373.6 370.0 366.0 -40.7
    net torque    1346. 1359. 1283. 1197. 1100. 1033.  972.  915.  -95.
 (max. net    engine torque of 1359.1 lb ft occurs at 1188. rpm)
 (max. gross engine torque of 1400.5 lb ft occurs at 1198. rpm)
   3.111 lb.ft.sec.2 engine inertia


 THIS SCAAN INFORMATION SUBJECT TO
 THE DISCLAIMER SET FORTH IN  TD-112


 REJECTED APPLICATION
```

BEST AVAILABLE COPY

SCAAN No 212910
date: 9/ 2/88, 2:18pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
SCAAN Application Information (cont)
====================================

VEHICLE: MILITARY WHEELED VEHICLE-SUPPORT
TACOM PROPULSION LAB. M915 ATEC/DDEC DEMONSTRATION PROG.
CONVERTER: TC-498 REF. TC-16611, 1-10-75
TRANSMISSION: ALLISON HT-755 CR
9544. lb.ft. max transm output torque, 1st range conv stall
24559. lb.ft. max transm output torque, rev range conv stall
TRANSM. APPLICATION- HT-755 CR EMERGENCY VEH,MOTOR HOME,SPECIALIZED VEH
12646 transm application library file number
Shift Calibration: 2100. rpm, HT(B)-755CR ATEC

upshift	mph	downshift	mph
1C-2C	7.77*	2C-1C	--
2C-2L	15.81*	2L-2C	--
2L-3L	24.34*	3L-2L	--
3L-4L	30.77*	4L-3L	--
4L-5L	38.91*	5L-4L	--

* Indicates data altered by ADAMS

THIS SCAAN INFORMATION SUBJECT TO
THE DISCLAIMER SET FORTH IN TD-112

REJECTED APPLICATION

```
 SCAAN No 212910
 date:  9/ 2/88,  2:18pm edt
 tm001127, ADAMS

           ALLISON TRANSMISSION DIV
      SCAAN Summary-  REJECTED Application
      ====================================
Vehicle        MILITARY WHEELED VEHICLE-SUPPORT
               TACOM PROPULSION LAB. M915 ATEC/DDEC DEMONSTRATION PROG.
Engine         DDC SERIES 60 400 GHP @ 2100 RPM (E46067321)
               (Clutch fan ENGAGED)
               (engine data responsibility: ADAMS)
Transmission   ALLISON HT-755 CR
Converter      TC-498 REF. TC-16611, 1-10-75

                                             recommendation      appli-
                                               or rating         cation  status
 ==============================================================================
  ENGINE:
--->ENGINE RATING/VOCATION COMPATIBILITY                                <------
---> SUBJECT TO ENGINE MFGRS. REVIEW                                    <------

  CONVERTER:
--->Stall turbine torque, lb.ft.          2600.max           2613. <-(XXX)
    Engine rpm, conv. stall               (----)             1734.
    Converter stall torque ratio          (----)             2.350
    Engine peak torque rpm vs min. rpm   1188.min            1729.  O.K.
    Conv. SR at 2100. gov rpm            0.750/1.000         0.783  O.K.

  TRANSMISSION:
    Input horsepower                       445.max            377.  O.K.
    Input torque, lb.ft. (lockup)         1380.max           1359.  O.K.
    Input rpm (gov.)                     1700./2800.         2100.  O.K.
    Transm output rpm, range 5 l.u.
     at 2100. rpm engine gov. speed       (----)             2100.

  VEHICLE/DRIVELINE:
--->Based on STANDARD MILITARY WHEELED VEHICLE-SUPPORT                 <-----
--->  road surface factor of  1.000  (NOT  1.400)                      <-----
    GCW lbs for  55.32 geared mph      130000.max           80320.  O.K.
    1st conv stall,                                                 O.K.
       tr.eff/wt on drive wheels ratio  0.4000 min          0.6640  O.K.
    1st gear conv. stall gradeability   (----)              29.56%
    1st conv. 70% eff. gradeability     (----)              21.23%
    1st conv. 80% eff. gradeability    12.00%min            17.66% O.K.
    1st conv. stall is insufficient to give 0.7 TE/weight

    Geared mph @ gov rpm, range 5 l.u.  (----)              55.32
    max mph  on  0.25% grade (clutch fan DISENGAGED)
     at 2143. engine rpm, range 5 l.u.  55.00min            56.44  O.K.

  ALL TRANSMISSION APPLICATIONS require submittal to
    TRANSMISSION ENGINEERING DEPARTMENT

  NOTE:  Symbols indicate:
--->Not within TRANSMISSION RATINGS      <-(XXX)
     SCAAN Summary-  REJECTED Application
     ====================================
```

SCAAN No 212910
date: 9/ 2/88, 2:18pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
Vehicle F.T. Gradeability Summary
Clutch Fan Engaged

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	gear range
-- (cannot negotiate grade) --					60.00	---	1C
5.45	1801	16510	15752	239.9	20.00	4681	1C
11.60	2093	8800	7992	272.3	10.00	2705	1C
15.57	2211	850	-2	35.4	0.00	1093	1C
-- (cannot negotiate grade) --					60.00	---	2C
-- (cannot negotiate grade) --					20.00	---	2C
10.44	1808	8790	7992	244.8	10.00	4448	2C
28.03	2195	1030	0	77.3	0.00	935	2C
-- (cannot negotiate grade) --					60.00	---	2LU
-- (cannot negotiate grade) --					20.00	---	2LU
-- (cannot negotiate grade) --					10.00	---	2LU
28.89	2195	1050	0	80.8	0.00	791	2LU
-- (cannot negotiate grade) --					60.00	---	3LU
-- (cannot negotiate grade) --					20.00	---	3LU
-- (cannot negotiate grade) --					10.00	---	3LU
36.30	2181	1190	0	114.9	0.00	747	3LU
-- (cannot negotiate grade) --					60.00	---	4LU
-- (cannot negotiate grade) --					20.00	---	4LU
-- (cannot negotiate grade) --					10.00	---	4LU
45.43	2161	1390	0	167.8	0.00	652	4LU
-- (cannot negotiate grade) --					60.00	---	5LU
-- (cannot negotiate grade) --					20.00	---	5LU
-- (cannot negotiate grade) --					10.00	---	5LU
56.02	2127	1660	0	247.5	0.00	779	5LU
-2.13	1804	42050	41324*	238.5	60.00	4749	R1C
-5.00	2120	16500	15752	220.0	20.00	2847	R1C
-5.59	2170	8750	7992	130.4	10.00	1372	R1C
-6.05	2221	750	-9	12.1	-0.01	988	R1C

REJECTED APPLICATION

SCAAN No 212910
date: 9/ 2/88, 2:18pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
Vehicle Full Throttle Performance
Clutch Fan Engaged

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	
Reverse 1, ratio= -9.648 -start, converter operation							
0.00	1734	59910	59195*	0.0	109.04	15867	
-2.00	1793	43382	42655*	231.4	62.67	5074	
-4.00	2030	25679	24937*	273.9	32.66	2734	
-4.17	2053	24530	23788	272.8	31.01	2747	.70 TE/WT ratio
-4.49	2100	22457	21711	268.8	28.08	2858	
-4.61	2104	21030	20279	258.3	26.09	2879	.60 TE/WT ratio
-4.97	2118	16768	16019	222.4	20.35	2919	
-6.00	2215	1673	915	26.8	1.14	984	
-6.04	2219	1071	313	17.2	0.39	985	
Forward 1, ratio= 3.692 -drive range start, converter operation							
0.00	1734	23282	22567	0.0	29.28	15867	
2.00	1732	21824	21096	116.4	27.22	10377	
2.58	1738	21030	20294	144.6	26.11	9060	.60 TE/WT ratio
4.00	1760	18823	18080	200.8	23.10	6459	
6.00	1821	15653	14895	250.4	18.87	4180	
7.77	1902	13030	12257	270.0	15.44	3120	
Forward 2, ratio= 2.002 -auto upshift, converter operation							
7.77	1765	10040	9267	208.1	11.62	6125	
8.00	1768	9933	9158	211.9	11.48	5949	
10.00	1800	8994	8200	239.8	10.26	4685	
12.00	1841	8089	7275	258.9	9.09	3767	
14.00	1894	7227	6390	269.8	7.98	3150	
15.81	1938	6551	5694	276.1	7.11	2778	
auto lockup shift							
15.81	1201	6422	5564	270.7	6.94	423	
16.00	1216	6416	5556	273.8	6.93	430	
18.00	1368	6148	5263	295.1	6.57	501	
20.00	1520	5792	4880	308.9	6.09	570	
22.00	1672	5448	4508	319.6	5.62	640	
24.00	1824	5063	4093	324.0	5.10	711	
24.34	1849	4980	4005	323.2	4.99	722	
Forward 3, ratio= 1.583 -auto upshift, auto lockup shift							
24.34	1463	4686	3711	304.2	4.63	516	
26.00	1562	4516	3515	313.1	4.38	558	
28.00	1683	4299	3265	321.0	4.07	609	
30.00	1803	4065	2997	325.2	3.73	662	
30.77	1849	3950	2868	324.1	3.57	682	

REJECTED APPLICATION

SCAAN No 212910
REJECTED APPLICATION

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min
Forward 4, ratio= 1.253 -auto upshift, auto lockup shift						
30.77	1463	3739	2657	306.8	3.31	397
32.00	1522	3661	2557	312.4	3.18	417
34.00	1617	3528	2386	319.9	2.97	451
36.00	1712	3388	2207	325.2	2.75	486
38.00	1807	3238	2017	328.1	2.51	523
38.91	1851	3152	1912	327.0	2.38	541
Forward 5, ratio= 1.000 -auto upshift, auto lockup shift						
38.91	1477	2958	1718	306.9	2.14	459
40.00	1518	2913	1650	310.7	2.05	479
42.00	1594	2828	1521	316.7	1.89	515
44.00	1670	2739	1387	321.4	1.73	551
46.00	1746	2647	1248	324.7	1.55	588
48.00	1822	2546	1098	325.8	1.37	625
50.00	1898	2417	920	322.3	1.15	663
52.00	1974	2300	752	319.0	0.94	701
54.00	2050	2191	590	315.6	0.73	738
55.32	2100	2123	486	313.2	0.61	763

Note: * exceeds vehicle traction limit

REJECTED APPLICATION

SCAAN No 212910
date: 9/ 2/88, 2:18pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
Vehicle Full Throttle Acceleration
Start With Brakes Locked
Clutch Fan Engaged

(on 0.00 percent grade)

speed mph	time sec	dist ft	accel mph/sec	eng rpm	gear range
1.00	0.18	0	5.621	1729	1C
2.00	0.36	1	5.327	1732	1C
3.00	0.55	1	4.929	1743	1C
4.00	0.77	2	4.488	1760	1C
5.00	1.00	4	4.048	1786	1C
6.00	1.27	6	3.621	1821	1C
7.00	1.56	9	3.216	1864	1C
7.77	1.82	12	2.931	1902	1C- 2C
8.00	1.91	13	2.416	1768	2C
9.00	2.34	18	2.286	1783	2C
10.00	2.79	24	2.156	1800	2C
12.00	3.78	40	1.914	1841	2C
14.00	4.90	62	1.677	1894	2C
15.81	6.05	87	1.487	1938	2C- 2L
16.00	6.19	90	1.398	1216	2L
18.00	7.66	127	1.330	1368	2L
20.00	9.23	171	1.232	1520	2L
22.00	10.92	223	1.139	1672	2L
24.00	12.77	285	1.037	1824	2L
24.34	13.11	297	1.010	1849	2L- 3L
26.00	14.89	363	0.909	1562	3L
28.00	17.18	454	0.845	1683	3L
30.00	19.66	559	0.776	1803	3L
30.77	20.68	605	0.739	1849	3L- 4L
32.00	22.49	688	0.670	1522	4L
34.00	25.59	838	0.626	1617	4L
36.00	28.93	1009	0.579	1712	4L
38.00	32.55	1206	0.530	1807	4L
38.91	34.32	1306	0.502	1851	4L- 5L
40.00	36.79	1449	0.436	1518	5L
42.00	41.59	1737	0.402	1594	5L
44.00	46.82	2067	0.367	1670	5L
46.00	52.59	2449	0.331	1746	5L
48.00	59.06	2895	0.292	1822	5L
50.00	66.61	3437	0.245	1898	5L
52.00	75.74	4121	0.201	1974	5L
54.00	87.13	5007	0.158	2050	5L
56.00	110.85	6932	0.027	2126	5L
56.02 = maximum speed					5L

(on 0.00 percent grade)

REJECTED APPLICATION

SCAAN No 212910
date: 9/ 2/88, 2:18pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
Engine-Converter Match
Clutch Fan Engaged

speed ratio	.engine.. rpm	torque	....turbine.... hp	rpm	torque	heat rej BTU/min	% power pkg eff	
0.0000	1734	1133	0.0	0	2613	15867	0.0	
0.1000	1729	1135	83.6	173	2541	12308	22.4	
0.2000	1737	1132	157.2	347	2377	9205	42.0	
0.3000	1755	1122	216.4	527	2159	6731	57.7	
0.3923	1786	1107	258.6	701	1938	4997	68.7	70 % eff
0.4000	1790	1105	261.5	716	1919	4879	69.5	
0.5000	1844	1072	292.6	922	1667	3553	77.7	
0.5104	1852	1067	295.0	945	1639	3441	78.4	80 % eff
0.5500	1885	1043	302.4	1037	1532	3060	80.7	
0.6000	1921	1020	309.7	1152	1411	2681	83.1	
0.6500	1967	991	315.0	1278	1294	2384	84.9	
0.7000	2010	966	317.5	1407	1185	2212	85.9	
0.7500	2060	937	316.3	1545	1075	2179	86.0	
0.7665	2080	926	314.9	1594	1037	2203	85.8	
0.7827	2100	915	312.9	1644	1000	2254	85.5	gov. rpm
0.7914	2102	902	307.7	1663	971	2259	85.2	
0.8000	2104	888	302.3	1683	943	2273	84.9	
0.8500	2115	811	271.4	1797	793	2343	83.1	
0.8600	2118	783	261.4	1822	753	2316	82.7	coupling
0.9000	2139	642	225.0	1925	614	1542	86.1	
0.9250	2154	536	194.1	1992	512	1101	88.2	
0.9500	2177	383	141.7	2068	360	719	89.3	

Lockup Operation

eng speed	...turb... torque	hp	% pwr pkg eff	
1100	1325	277.5	98.4	
1200	1338	305.7	98.5	
1233	1335	313.4	98.5	conv-lockup intersection
1400	1262	336.4	98.4	
1600	1176	358.2	98.2	
1800	1079	369.7	98.1	
1900	1012	366.0	98.0	
2000	951	362.0	97.8	
2100	894	357.6	97.7	gov. rpm
2100	894	357.6	97.7	
2138	629	255.8	96.8	
2175	372	154.0	94.7	
2213	124	52.2	85.5	

REJECTED APPLICATION

SCAAN No 212922
date: 9/ 2/88, 4:06pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
SCAAN Application Information
============================

---> HT-754 CR <---
---> NOT APPROVED with MILITARY WHEELED VEHICLE-SUPPORT <---

VEHICLE: MILITARY WHEELED VEHICLE-SUPPORT
TACOM PROPULSION LAB. M915A1 LINEHAUL TRACTOR
7011 vocation library file number
80320. lbs. gross combination weight
35044. lbs. weight on drive wheels (43.6 percent)
19.657 in. radius, wheel- bias tires (ATD rolling resist)
513.00 wheel rev/mile
18 total tires in contact with road
4.440 driveline reduction ratio, total
driveline: propeller shaft, tandem axle
90.00 % driveline efficiency
(efficiency value responsibility: ADAMS)
136.41 lb.ft.sec.2 driveline equivalent inertia
0.700 traction limit coefficient
1.4000 road surface factor
13.50 x 8.00 ft. vehicle height x width
0.7500 air resistance coefficient
DIESEL ENGINE: CUMM NTC-400 CY80, CY81 (20163)
(engine data responsibility: ADAMS)
(NOTE: ENGINE RATING/VOCATION COMPATIBILITY
SUBJECT TO ENGINE MFGRS. REVIEW)
997616 engine library file number
400.0 gross horsepower at 2100. rpm
deductions- (hp. at 2100. rpm)
28.0 hp fan (clutch engaged)
0.0 hp fan (clutch disengaged)
2.0 hp alternator/generator
2.0 hp air compressor
2.0 hp steer pump
366.0 net horsepower 2100. rpm

eng rpm	1300.	1400.	1500.	1600.	1700.	1800.	1900.	2100.	2460.
entered hp	276.7	303.9	328.4	347.9	365.4	378.7	390.0	400.0	0.0
net hp	265.6	290.9	313.3	330.5	345.3	355.6	363.6	366.0	-51.7
net torque	1073.	1091.	1097.	1085.	1067.	1038.	1005.	915.	-110.

(max. net engine torque of 1097.1 lb ft occurs at 1494. rpm)
(max. gross engine torque of 1149.9 lb ft occurs at 1506. rpm)
3.760 lb.ft.sec.2 engine inertia

THIS SCAAN INFORMATION SUBJECT TO
THE DISCLAIMER SET FORTH IN TD-112

REJECTED APPLICATION

SCAAN No 212922
date: 9/ 2/88, 4:06pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
SCAAN Application Information (cont)
====================================

---> HT-754 CR <---
---> NOT APPROVED with MILITARY WHEELED VEHICLE-SUPPORT <---

VEHICLE: MILITARY WHEELED VEHICLE-SUPPORT
TACOM PROPULSION LAB. M915A1 LINEHAUL TRACTOR
CONVERTER: TC-498 REF. TC-16611, 1-10-75
TRANSMISSION: ALLISON HT-754 CR (3.69 LOW GR.)STD.
9004. lb.ft. max transm output torque, 1st range conv stall
23171. lb.ft. max transm output torque, rev range conv stall
TRANSM. APPLICATION- HT-754 CR
12136 transm application library file number
Shift Calibration: 2100. rpm, HT-754CR (3.69 LOW)

upshift	mph	downshift	mph
1C-2C	14.98*	2C-1C	--
2C-2L	23.84	2L-2C	22.00
2L-3L	26.74	3L-2L	23.97
3L-4L	33.85	4L-3L	30.42
4L-5L	43.46	5L-4L	39.64

* Indicates non-standard data

THIS SCAAN INFORMATION SUBJECT TO
THE DISCLAIMER SET FORTH IN TD-112

REJECTED APPLICATION

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 SCAAN No 212922
 date:  9/ 2/88,  4:06pm edt
 tm001127, ADAMS

            ALLISON TRANSMISSION DIV
        SCAAN Summary-  REJECTED Application
         =================================
Vehicle         MILITARY WHEELED VEHICLE-SUPPORT
                TACOM PROPULSION LAB. M915A1 LINEHAUL TRACTOR
Engine          CUMM NTC-400 CY80, CY81 (20163)
                (Clutch fan ENGAGED)
                (engine data responsibility: ADAMS)
Transmission    ALLISON HT-754 CR (3.69 LOW GR.)STD.
Converter       TC-498 REF. TC-16611, 1-10-75

                                      recommendation      appli-
                                        or rating         cation  status
 =====================================================================
  ENGINE:
--->ENGINE RATING/VOCATION COMPATIBILITY                          <------
---> SUBJECT TO ENGINE MFGRS. REVIEW                              <------

  CONVERTER:
    Stall turbine torque, lb.ft.        2600.max          2466.  O.K.
    Engine rpm, conv. stall             (----)            1683.
    Converter stall torque ratio        (----)            2.350
    Engine peak torque rpm vs min. rpm  1494.min          1678.  O.K.
--->Conv. SR at 2100. gov rpm          0.800/1.000        0.783 <--(XX)

  TRANSMISSION:
--->Not acceptable with MILITARY WHEELED VEHICLE-SUPPORT         <-(XXX)
    Input horsepower                     445.max           367.  O.K.
    Input torque, lb.ft. (lockup)       1380.max          1097.  O.K.
    Input rpm (gov.)                   1800./2100.        2100.  O.K.
    Transm output rpm, range 5 l.u.
     at 2100. rpm engine gov. speed     (----)            2100.

  VEHICLE/DRIVELINE:
--->Based on STANDARD MILITARY WHEELED VEHICLE-SUPPORT            <-----
--->  road surface factor of  1.000  (NOT  1.400)                 <-----
    GCW lbs for  55.32 geared mph     130000.max         80320.  O.K.
    1st conv stall,                                              O.K.
       tr.eff/wt on drive wheels ratio  0.4000 min       0.6270  O.K.
    1st gear conv. stall gradeability   (----)            27.72%
    1st conv. 70% eff. gradeability     (----)            20.16%
    1st conv. 80% eff. gradeability    12.00%min          17.02% O.K.
    1st conv. stall is insufficient to give 0.7 TE/weight

    Geared mph @ gov rpm, range 5 l.u.  (----)            55.32
    max mph  on  0.25% grade (clutch fan DISENGAGED)
     at 2191. engine rpm, range 5 l.u.  55.00min          57.71  O.K.
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 SCAAN No 212922
 date:  9/ 2/88,  4:06pm edt
 tm001127, ADAMS

           ALLISON TRANSMISSION DIV
     SCAAN Summary-  REJECTED Application (cont)
     =========================================
Vehicle        MILITARY WHEELED VEHICLE-SUPPORT
               TACOM PROPULSION LAB. M915A1 LINEHAUL TRACTOR
Engine         CUMM NTC-400 CY80, CY81 (20163)
               (Clutch fan ENGAGED)
               (engine data responsibility: ADAMS)
Transmission   ALLISON HT-754 CR (3.69 LOW GR.)STD.
Converter      TC-498 REF. TC-16611, 1-10-75

                                   recommendation    appli-
                                     or rating       cation  status
 ===================================================================
  VEHICLE/DRIVELINE: (cont)

  ALL TRANSMISSION APPLICATIONS require submittal to
    TRANSMISSION ENGINEERING DEPARTMENT

  NOTE:   Symbols indicate:
--->Not within TRANSMISSION RATINGS      <-(XXX)
--->Not within PERFORMANCE REQUIREMENTS <--(XX)
     SCAAN Summary-  REJECTED Application
     ==================================
```

SCAAN No 212922
date: 9/ 2/88, 4:06pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
Vehicle F.T. Gradeability Summary
Clutch Fan Engaged

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	gear range
-- (cannot negotiate grade) --					60.00	---	1C
4.82	1741	16500	15752	212.0	20.00	4863	1C
11.60	2092	8800	7992	272.2	10.00	2707	1C
16.61	2351	860	-3	38.2	-0.01	1368	1C
-- (cannot negotiate grade) --					60.00	---	2C
-- (cannot negotiate grade) --					20.00	---	2C
9.31	1749	8780	7992	218.0	10.00	4614	2C
29.64	2314	1060	0	83.8	0.00	1075	2C
-- (cannot negotiate grade) --					60.00	---	2LU
-- (cannot negotiate grade) --					20.00	---	2LU
-- (cannot negotiate grade) --					10.00	---	2LU
30.46	2315	1080	0	87.4	0.00	860	2LU
-- (cannot negotiate grade) --					60.00	---	3LU
-- (cannot negotiate grade) --					20.00	---	3LU
-- (cannot negotiate grade) --					10.00	---	3LU
37.96	2281	1220	0	123.6	0.00	800	3LU
-- (cannot negotiate grade) --					60.00	---	4LU
-- (cannot negotiate grade) --					20.00	---	4LU
-- (cannot negotiate grade) --					10.00	---	4LU
46.92	2232	1420	0	177.8	0.00	686	4LU
-- (cannot negotiate grade) --					60.00	---	5LU
-- (cannot negotiate grade) --					20.00	---	5LU
-- (cannot negotiate grade) --					10.00	---	5LU
56.80	2156	1680	0	254.2	0.00	796	5LU
-1.88	1745	42050	41324*	211.3	60.00	4911	R1C
-5.08	2144	16500	15752	223.6	20.00	2832	R1C
-5.84	2257	8750	7993	136.2	10.00	1414	R1C
-6.49	2376	750	-13	13.0	-0.02	1343	R1C

REJECTED APPLICATION

SCAAN No 212922
date: 9/ 2/88, 4:06pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
Vehicle Full Throttle Performance
Clutch Fan Engaged

veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min	
Reverse 1, ratio= -9.648 -start, converter operation							
0.00	1683	56523	55808*	0.0	96.61	14551	
-2.00	1756	40944	40216*	218.4	57.84	4626	
-4.00	2028	25579	24837*	272.8	32.52	2725	
-4.16	2051	24530	23788	272.3	31.01	2742	.70 TE/WT ratio
-4.49	2100	22457	21711	268.8	28.08	2858	
-4.62	2108	21030	20279	259.2	26.09	2897	.60 TE/WT ratio
-5.02	2136	17063	16313	228.3	20.74	2985	
-6.00	2287	6754	5996	108.1	7.49	1276	
-6.49	2376	748	-13	13.0	-0.02	1343	
Forward 1, ratio= 3.692 -drive range start, converter operation							
0.00	1683	21966	21250	0.0	27.43	14551	
1.53	1679	21030	20301	86.0	26.12	10473	.60 TE/WT ratio
2.00	1682	20513	19785	109.4	25.42	9387	
4.00	1717	17702	16960	188.8	21.60	5836	
6.00	1789	14848	14091	237.6	17.82	3849	
8.00	1898	12413	11637	264.8	14.64	2938	
10.00	2005	10340	9545	275.7	11.97	2585	
11.73	2100	8678	7867	271.4	9.84	2734	
12.00	2107	8243	7428	263.8	9.29	2772	
13.11	2136	6575	5748	229.8	7.17	2912	
14.00	2179	5384	4547	201.0	5.67	2187	
14.98	2237	3853	3005	153.9	3.74	1558	
Forward 2, ratio= 2.002 -auto upshift, converter operation							
14.98	1903	6689	5841	267.3	7.29	2837	
16.00	1934	6373	5513	271.9	6.88	2683	
18.00	1993	5782	4897	277.6	6.11	2492	
20.00	2049	5215	4303	278.1	5.37	2470	
21.63	2100	4760	3625	274.6	4.77	2585	
22.00	2105	4587	3648	269.1	4.55	2605	
23.84	2129	3790	2823	240.9	3.52	2748	
auto lockup shift							
23.84	1811	4817	3849	306.2	4.80	698	
24.00	1824	4797	3828	307.0	4.77	704	
26.00	1976	4523	3522	313.6	4.39	778	
26.74	2032	4398	3385	313.6	4.22	805	
Forward 3, ratio= 1.583 -auto upshift, auto lockup shift							
26.74	1607	4017	3005	286.4	3.74	563	
28.00	1683	3963	2930	295.9	3.65	598	
30.00	1803	3830	2762	306.4	3.44	653	

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veh mph	engine rpm	tr effort	drawbar pull	wheel hp	net % grade	tran ht BTU/min
32.00	1923	3672	2568	313.3	3.20	710
33.85	2034	3484	2345	314.4	2.92	764

Forward 4, ratio= 1.253 -auto upshift, auto lockup shift

33.85	1610	3207	2068	289.5	2.58	443
34.00	1617	3203	2061	290.4	2.57	445
36.00	1712	3145	1964	301.9	2.45	482
38.00	1807	3056	1835	309.6	2.28	520
40.00	1903	2958	1695	315.5	2.11	561
42.00	1998	2837	1530	317.7	1.90	603
43.46	2067	2733	1393	316.8	1.73	636

Forward 5, ratio= 1.000 -auto upshift, auto lockup shift

43.46	1650	2527	1187	292.9	1.48	541
44.00	1670	2517	1165	295.3	1.45	551
46.00	1746	2471	1072	303.1	1.34	588
48.00	1822	2411	964	308.6	1.20	625
50.00	1898	2348	851	313.1	1.06	663
52.00	1974	2273	725	315.2	0.90	701
54.00	2050	2187	585	314.9	0.73	738
55.32	2100	2123	486	313.2	0.61	763
56.00	2126	1916	260	286.1	0.32	778
56.80	2156	1678	0	254.2	0.00	796

Note: * exceeds vehicle traction limit

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date: 9/ 2/88, 4:06pm edt
tm001127, ADAMS
REJECTED APPLICATION

ALLISON TRANSMISSION DIV
Vehicle Full Throttle Acceleration
Start With Brakes Locked
Clutch Fan Engaged

(on 0.00 percent grade)

speed mph	time sec	dist ft	accel mph/sec	eng rpm	gear range
1.00	0.19	0	5.283	1678	1C
2.00	0.38	1	4.979	1682	1C
3.00	0.59	1	4.588	1695	1C
4.00	0.82	3	4.168	1717	1C
5.00	1.08	4	3.755	1748	1C
6.00	1.36	6	3.365	1789	1C
7.00	1.68	10	3.013	1842	1C
8.00	2.03	13	2.754	1898	1C
9.00	2.41	18	2.491	1953	1C
10.00	2.83	24	2.266	2005	1C
12.00	3.83	40	1.868	2107	1C
14.00	5.25	68	1.115	2179	1C
14.98	6.37	91	0.744	2237	1C- 2C
16.00	7.06	107	1.439	1934	2C
18.00	8.55	144	1.280	1993	2C
20.00	10.23	191	1.125	2049	2C
22.00	12.16	250	0.973	2105	2C
23.84	14.34	324	0.745	2129	2C- 2L
24.00	14.51	330	0.958	1824	2L
26.00	16.69	410	0.885	1976	2L
26.74	17.54	443	0.851	2032	2L- 3L
28.00	19.20	509	0.753	1683	3L
30.00	21.94	626	0.711	1803	3L
32.00	24.86	759	0.662	1923	3L
33.85	27.80	901	0.603	2034	3L- 4L
34.00	28.08	915	0.538	1617	4L
36.00	31.89	1111	0.513	1712	4L
38.00	35.94	1330	0.480	1807	4L
40.00	40.29	1579	0.444	1903	4L
42.00	45.05	1866	0.401	1998	4L
43.46	48.90	2107	0.365	2067	4L- 5L
44.00	50.64	2218	0.307	1670	5L
46.00	57.44	2667	0.283	1746	5L
48.00	64.92	3184	0.255	1822	5L
50.00	73.33	3788	0.225	1898	5L
52.00	83.00	4512	0.192	1974	5L
54.00	94.65	5418	0.156	2050	5L
56.00	111.20	6756	0.079	2126	5L

56.80 = maximum speed 5L
(on 0.00 percent grade)

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ALLISON TRANSMISSION DIV
Engine-Converter Match
Clutch Fan Engaged

speed ratio	.engine.. rpm	torque	....turbine.... hp	rpm	torque	heat rej BTU/min	% power pkg eff	
0.0000	1683	1070	0.0	0	2466	14551	0.0	
0.1000	1678	1071	76.5	168	2394	11274	22.4	
0.2000	1687	1070	144.1	337	2244	8456	42.0	
0.3000	1708	1065	199.6	513	2046	6224	57.6	
0.3923	1744	1055	240.5	684	1847	4662	68.6	70 % eff
0.4000	1747	1054	243.4	699	1829	4555	69.4	
0.5000	1811	1034	277.1	905	1607	3375	77.7	
0.5104	1820	1031	280.1	929	1584	3280	78.4	80 % eff
0.5500	1862	1018	291.2	1024	1494	2954	80.7	
0.6000	1905	1003	302.2	1143	1388	2621	83.0	
0.6500	1957	983	310.8	1272	1283	2354	84.8	
0.7000	2005	962	315.5	1404	1180	2200	85.9	
0.7500	2058	937	315.8	1544	1074	2176	86.0	
0.7665	2079	926	314.7	1594	1037	2202	85.8	
0.7827	2100	915	312.9	1644	1000	2254	85.5	gov. rpm
0.7914	2104	903	308.4	1665	973	2265	85.2	
0.8000	2107	891	303.8	1686	947	2283	85.0	
0.8500	2129	822	276.9	1809	804	2386	83.1	
0.8600	2136	796	268.1	1837	766	2370	82.8	coupling
0.9000	2178	665	237.6	1960	637	1615	86.2	
0.9250	2211	564	209.9	2045	539	1170	88.4	
0.9500	2263	412	159.2	2150	389	777	89.7	

Lockup Operation

eng speed	...turb... torque	hp	% pwr pkg eff	
1300	1052	260.4	98.0	
1400	1070	285.3	98.1	
1500	1076	307.3	98.1	
1546	1073	315.8	98.1	conv-lockup intersection
1600	1064	324.1	98.1	
1700	1046	338.5	98.0	
1800	1017	348.4	98.0	
1900	984	356.0	97.9	
2100	894	357.6	97.7	gov. rpm
2100	894	357.6	97.7	
2190	607	253.3	96.7	
2280	343	148.7	94.2	
2370	97	43.8	82.2	

REJECTED APPLICATION

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Repower and Regear of an M915 Line Haul Tractor to Demonstrate Feasibility of Commercial Electronic Controls and Air Starters (Unclassified)

12. PERSONAL AUTHOR(S)
Adams Bernard Eugene

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19. ABSTRACT *(Continue on reverse if necessary and identify by block number)*

The M915 ATEC/DDEC Demonstrator Program consisted of the repower/regear of a U.S. Army M915 Line Haul Tractor, testing and demonstration/evaluation by the Government. The vehicle was repowered with a Detroit Diesel Series 60 engine and regeared with an Allison HT 755CR transmission. Both components included commercially-available electronic controls. Also included as part of the repower was a "Pow-R-Quik" engine air starter. The testing, demonstration, and evaluation was accomplished at several locations. Shakedown and vehicle performance testing occurred at General Motors Proving Grounds in Milford, Michigan. High Altitude Electro-Magnetic Pulse (HAEMP) testing was performed at the Government's White Sands Missile Range and is covered in a separate, classified Appendix to this report. Demonstrations for the Government took place at Milford Proving Grounds and at the Tank-Automotive Command in Warren, Michigan. End user evaluation of the demonstrator vehicle was carried out at Fort Campbell, Kentucky.

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